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Innovative Operational Treatment Technologies for Application to Superfund Site: Nine Case Studies

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16. ABSTRACT

Nine case studies are presented in a report that was designed to identify and obtain operational data from ongoing and completed remediation efforts. The case studies are presented as appendices, and provide process descriptions, performance, operational and cost data. The nine appendices present case studies on the following topics.

Incineration of Explosives and Contaiminated soils. Goundwater Extraction With Air Stripping, Groundwater Biodegradation Treatment System, Ground Extraction and Treatment, Groundwater Extraction with Air Stripping and Soil Vacuum Extraction, Groundwater Extraction With Physical Chemical & Biological Treatment, and Chemical Treatment of Groundwater and Soil Flushing.

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Innovative Operational Treatment Technologies for Application to Superfund Site – Nine Case Studies

Final Report

ERG Subcontract No. EPA-CERI/1
EPA Contract No. 68-C8-0011
EPA Work Assignment No. 18

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DISCLAIMER

This final report was furnished to Eastern Research Group, Inc. and the Environmental Protection Agency (EPA) by Alliance Technologies Corporation, Bedford, Massachusetts 01730, in fulfillment of ERG Subcontract No. EPA-CERI/1, Work Assignment No. 18 (EPA Contract No. 68-C8-0011). The opinions, findings, and conclusions expressed are those of the authors and not necessarily those of ERG, EPA or cooperating individuals.

The case studies presented in the appendices to this report were prepared based on data provided to Alliance Technologies Corporation by various sources. Alliance recognizes that significant data gaps and inconsistencies may exist in the case studies because the degree of data quality and completeness could not be defined. Based on these findings and recommendations from EPA representatives who reviewed the draft report, the cases may be supplemented at a future date through field visits, office visits, and associated engineering evaluations of available additional data. In the absence of more in-depth evaluations and efforts to define data quality and establish consistency in the level of detail among the cases, extrapolation from the cases in a general fashion or to specific sites should be done with caution, if at all.

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The authors wish to express their thanks to Mr. Thomas Pheiffer of EPA's Office of Solid Waste and Emergency Response for his guidance during the course of this project. Others who contributed to the successful completion of this project through review of the draft report include Benjamin Blaney (RREL), Gordon Evans, Michael Cummins (EPA Water Supply Technology Branch), and James Kreissl (Chief, EPA Municipal Wastewater Pollution Control Section. Case specific information presented in the appendices was received through the cooperation of several individuals in the EPA regions, the Department of Defense, and elsewhere. They include:

Fran Allens, EPA Region 5
Glen Curtis, EPA Region 7
Doug Downey, DoD
Robert Forster, Lakewood Water District
Chet Janowski, EPA Region 1
Doug MacKensie, DoD
Lauren McPhillips, EPA Region 10
Janet O'Hara, EPA Region 10
Randy Pratt, CH2M Hill
Robert Turkeltaub, DoD

Others who provided assistance during the project include:

Walter Johnson, EPA Hazardous Site Control Division
Joseph Lafornara, EPA Emergency Response Technical Support Team
Michael Mastracci, EPA Office of Research and Development
Scott Smith, Andrews AFB
Robert York, USATHAMA

Many other individuals too numerous to mention, representing a variety of agencies and organizations also provided assistance during the study.

SECTION 1

INTRODUCTION

With the profusion of hazardous waste sites requiring remediation and the multitude of existing and innovative treatment technologies now available, it is increasingly important to assemble technology performance and cost data so that site remediation planners can select technologies for future Superfund site applications based on "real world" experience. Further, EPA should implement a standard system to provide for the centralized cataloging of site specific hazardous waste treatment data so that site planners can efficiently access such information. Both of these topics are addressed in this report.

In November, 1988, Alliance Technologies Corporation initiated a screening study to determine the availability of performance and cost data for full scale, field demonstrated, hazardous waste treatment technologies. Alliance targeted EPA regions (i.e., RPMs), States, DOE, DoD, and vendors to develop a list of sites. The CERCLIS data base was also accessed. Ultimately, 20 sites (falling under the jurisdiction of Superfund, DoD, and DOE) were designated for further investigation based on preliminary indications of the scope of data available and ease of data acquisition. As the project progressed and priorities evolved, we were able to assemble 9 case studies, as incorporated in the appendices. Field visits or office visits were not conducted; all information was obtained through verbal and written requests. Considering the difficulties that we encountered in identifying sources of information and then in obtaining comprehensive site specific information, our concerns began to focus on the need for a system for automatic cataloging of this type of data to allow rapid access to site- or technology-specific performance data. Thus, the discussions that follow provide a review of the overall project (Section 2), our experience in accessing data (Section 3), and recommendations for implementing a standardized system for storage and retrieval of treatment technology performance data (Section 4). Case studies are presented in Appendices A through I.

The case studies were developed based on varying information provided by a variety of sources. Consequently, inconsistencies exist among the cases relative to depth of coverage and data quality, completeness, and reliability. As noted elsewhere in this report, measures of data quality were not generally available so that extrapolation from the cases in a general fashion or to specific sites should be done with caution, if at all.

A draft version of this report was submitted to EPA for review and comment. The report and appended case studies were reviewed by representatives at EPA Headquarters and EPA's Risk Reduction Engineering Laboratory in Cincinnati. Commenters agreed that these cases should be supplemented with additional data (see Section 4) and that future efforts to develop case information of this type should be based on field visits, office visits, and associated engineering evaluations to enhance the level of detail, provide for more consistent detail throughout all cases, and to define data quality.

SECTION 2
REVIEW OF PROJECT

The purpose of this work assignment was to identify and obtain operational data from ongoing and completed site remediation efforts independent of EPA's SITE program demonstrations. Emphasis was placed on conventional and innovative technologies currently available and operating at full scale in the United States.

We planned to implement the project in three phases, as summarized below:

- Phase 1 - Identify the scope and quality of operational data on site remediation programs through contacts with states, EPA Remedial Project Managers (RPMS), Department of Defense (DoD) and Department of Energy (DOE) Remedial Project Managers, technology vendors, and industry contacts, where possible.

- Phase 2 - Review and analyze the results from Phase 1 for quality and value to the program; then prepare case studies of those sites. A status report describing the selected sites and technological information was part of this phase.

- Phase 3 - Develop and submit a final report of all reviewed data to EPA, including the case studies and recommendations for future data collection and organization efforts. This report is the outcome of the third phase of this project.

CHANGES AS WORK PROCEEDED

This project required research of Federal, State, local and private organizations to identify remediation projects which could be of value to the study. Initial contacts with EPA, DoD, DOE, and vendors indicated that a significant number of sites existed where some form of remedial action had taken place or was currently being pursued. The majority of these sites were undergoing or had completed a remedial action under the following mandates:

1. CERCLA Remedial Action (post-Record of Decision)
2. CERCLA Emergency Response Action (pre-Record of Decision)
3. RCRA Corrective Action
4. DoD and DOE Facility Remedial Actions

Based on these initial inquiries, the potential number of sites that could have been identified in these categories was as high as five hundred to one thousand sites. Because characterizing this number of sites was clearly beyond the scope of the project, Alliance agreed with the EPA Technical Project Monitor that the remedial technologies to be pursued should be those implemented under Superfund Remedial Action Plans, and any DoD/DOE facilities. This decision was primarily the result of EPA's need for an analysis of the costs associated with Superfund clean-ups to date, in conjunction with the desire to characterize innovative treatment technologies. Therefore, it was decided to cease any further investigation of remedial actions under RCRA, or Emergency Response.

Inquiries made in relation to RCRA Corrective Actions did reveal a significant effort in some EPA regions, particularly in Region IV, in terms of optimizing the reporting, storing, and evaluation of full scale performance data. As later discovered for the Superfund Program, RCRA Corrective Actions have not involved many innovative treatment technologies. However, a substantial amount of data has been compiled in Region IV on ground water treatment systems and aquifer restoration programs. As discussed later in this report, regional initiatives developed to track remedial actions should be identified (whether under RCRA or CERCLA), to facilitate the implementation of a central EPA database on a system like the Office of Research and Development's "Alternative Treatment Technology Information Center" (ATTIC).

FACILITY SCREENING

The initial identification of candidate sites was accomplished through contacts with OSWER, ORD, the Emergency Response Team in Edison NJ, EPA Remedial Project Managers, RCRA personnel, States, DoD and DOE Remedial Project Managers, and technology vendors.

Two data forms were used to record preliminary information collected by telephone. First, a primary contact sheet was completed, including the identity of the contact, any first hand knowledge of ongoing or completed remedial actions, and any leads provided. If leads to the existence of an operating full scale treatment technology were developed, then a second form, the Site Data Summary sheet, was completed. This form included the name of the contact, the site name and location, a brief site history, the present status of the site, the remediation start-up time, the technologies operating at the site, and the availability, source, and accessibility of performance and cost data. Copies of these forms are included in Appendix J.

The most detailed follow-up of ongoing or completed treatment technologies focused on Superfund Remedial Actions. The following paragraphs summarize the contacts that were made in each of the different organizations and EPA offices contacted.

EPA Headquarters

Contacts were made within the Office of Solid Waste and Emergency Response, and the Office of Research and Development, to identify key field personnel familiar with ongoing or completed remedial actions, and to acquire output from EPA tracking systems (i.e., CERCLIS) to assist in locating candidate sites.

Mr. Walter Johnson, EPA Hazardous Site Control Division, was contacted to obtain a printout from CERCLIS referencing only those sites where a Remedial Action was ongoing or completed. This served as a resource for checking CERCLA sites identified by contacts during the screening phase of this project. Each of the listed sites was then discussed with the Regional Superfund Chiefs and/or the Regional Project Managers (if not discussed previously in Phase 1) to ensure that all the sites of interest to this effort were characterized.

Alliance also obtained a copy of the Record of Decision (ROD) Ground Water Remediation database for FY '82 through '86. As with CERCLIS, the database was used as a tool to verify and screen sites for selection purposes.

Office of Research and Development (ORD)

Alliance contacted Michael Mastracci at ORD to coordinate data collection efforts with any similar activities underway in support of the ORD clearinghouse. Mr. Mastracci indicated that he was currently working on a QA/QC process to ensure consistent and high quality data for input to a remedial database or clearinghouse, called the Alternative Technology Treatment Information Center (ATTIC). Alliance and ORD agreed to coordinate efforts to ensure that Alliance's data compilation activities could also serve as input to the clearinghouse. Mr. Mastracci's primary concern was to establish sources of high quality data for storage and access.

As discussed in Section 3 of this report, many of the problems Alliance encountered in locating and accessing performance data were the result of a failure to compile information in any systematic form at the point of generation. The importance and value of a system such as ATTIC, in conjunction with disciplined procedures to ensure valid input, is clear.

Contacts were made within ORD's Risk Reduction and Engineering Laboratory (RREL), in Cincinnati, Ohio. RREL staff referred us to several contacts in the EPA regions with first-hand knowledge of operating technologies.

Emergency Response Technical Support Team, Edison, NJ

In addition to locating CERCLA sites with ongoing or completed remedial actions implemented subsequent to a ROD, Alliance contacted EPA Emergency Response personnel to identify sites where interim remedial activities or emergency actions had been implemented prior to completion of the RI/FS. Mr. Joseph Lafornara provided access to the Emergency Response Data Base for "proposed" site clean ups, maintained by the Edison Technical Support Team. Alliance evaluated approximately 75 sites.

Information provided from the database was investigated by contacting the lead team member for the site(s). In virtually all cases, site factors did not fit the criteria for this project. Examples of such problems included: Clear Creek, CO - SITE project; Conrail Derailment - field test was unsuccessful and no data were available; Poly-Carb Site Wells, NV - Treatability Study; Union Chemical Site, Maine - off-site disposal; and, Texarkana Wood Preserving Site -volatiles evaporated, site had no cleanup.

Contacts were also made in the Emergency and Remedial Response Branches of each EPA region to cross-check the Edison data base. Alliance contacted On-Scene Coordinators in some regions in an attempt to locate applicable performance data.

EPA Regions

From contacts with Regional Superfund Chiefs and, subsequently, Remedial Project Managers (RPMs), Alliance identified 15 Superfund sites with operational hazardous waste remediation facilities where performance and cost data were available. The EPA RPMs proved to be the primary sources of information relevant to this project.

Alliance accessed the OSWER Electronic Bulletin Board, sending an open request to users for assistance in identifying any sites with available and accessible performance data. However, we did not receive any responses.

Department of Defense (DoD)/Department of Energy (DOE)

Numerous contacts were made with the DoD and Department of Energy to identify sites potentially applicable to this project. Alliance contacted the Directors of the Environmental Divisions from each branch of the military (Army, Navy, and Air Force) and several executive offices of the DOE. As a result, Alliance was referred to others in DoD and DOE with more direct project responsibility who provided leads to several sites. After contacting DOE's Office of Fossil Energy in Washington, the Deputy Assistant Secretary of Environment, and the Director of Waste Management in Oak Ridge, Tennessee through letters and by telephone, the DOE indicated several sites for possible consideration. However, the eight sites identified were sensitive DoD facilities going through RCRA Section 3004(U) closures. Because related information would have been difficult to obtain and the project focus had shifted to Superfund sites, these DOE managed facilities were not pursued.

Although DoD provided several potential case studies, many of the suggested sites were operating at early stages, conducting treatability studies or bench-scale studies. Of those sites which were applicable to the data collection effort, we encountered some difficulties in accessing data. In some cases, we were told that cost information was not available and/or not maintained, or that the site was involved in litigation (i.e. Rocky Mountain Arsenal) and the attorneys would prefer not to relinquish any information. Information availability regarding DoD sites was limited, as a result.

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA)

All Army hazardous waste remediation sites are managed by the Installation Restoration Division of USATHAMA at the Abeerding Proving Grounds, Maryland. Additionally, site specific details were provided by Project Managers at the individual sites throughout the country. The acting chief of the Installation Restoration Division (IRD), Dr. Robert York, provided leads for six potentially applicable sites. After contacting project personnel, Alliance obtained performance data for a ground water recovery system at the Twin City Army Ammunition Depot in New Brighton, Minnesota, and for a portable incinerator unit at the Cornhusker Army Ammunition Depot in Nebraska. The other candidates sites included carbon absorption units, but Alliance was unable to obtain performance data despite repeated requests to the project contacts.

U.S. Air Force

The Air Force has 13 commands which include 10 to 20 bases per command. At this time, five to six commands are actively pursuing hazardous waste site cleanups. While no database describing the sites and the stage of remediation exists, several sources were able to indicate sites with potential applicability to this project. Major Scott Smith, Environmental Operations Branch, Environmental Division, Andrews AFB, suggested two sites including the Wurtsmith AFB and McClellan AFB. Alliance obtained information relevant to the McClellan AFB remedial operations which include ground water extraction, incineration, and bioremediation facilities. Another source, Doug Downey, Environics, Tyndall AFB, provided research and cost information relative to a full-scale bioremediation project at Eglin AFB.

U.S. Navy

Naval hazardous waste facilities in the process of remediation are handled by the Naval Energy and Environmental Support Activity (NEESA). An installation restoration database exists which was sorted to provide a listing of facilities in or having completed the Remedial Design/Remedial Action Phase. At the time of our review, there were 23 remedial actions with 11 completed. The clean up actions at these eleven sites involved off site removal or capping. Several other remedial actions remain in the design phase. Consequently, the naval sites were not pursued.

State, Local, and Private Contacts

In a few instances, EPA Regional contacts referred Alliance to State contacts for sites with State-leads. State contacts included: Mr. Mike Vennowitz, Project Manager and Mr. Justin Blum for the Reilly Tar site in Minnesota.

Other sites were investigated by contacting local government sources. They included: Mr. James Grube for the Reilly Tar site in Minnesota; Mr. Sam Spanel for the Eau Claire site in Wisconsin; and Mr. Bob Forster for the Ponders Corner site in Washington.

Finally, in two instances, other government contractors were contacted for information. They included Black and Veatch for the South Tacoma/ Commencement Bay site in Washington, and CH2M Hill for the United Chrome site in Oregon.

Vendor Contacts

A number of potentially useful sites were identified through contacting vendors, but the full-scale operational technologies identified were predominately containment and off-site treatment and, consequently, of secondary interest to this study. Although three sites were noted that involved incineration or bioremediation, their identity and accessibility to performance and cost data was limited due to client-vendor confidentiality agreements. For these reasons, the use of vendors was not highly emphasized in Phase 2. Many of the vendors that were contacted indicated that the use of innovative treatment technologies at Superfund sites, outside of the Superfund Innovative Technology Evaluation (SITE) program, was very limited in their experience.

RATIONALE FOR SELECTION OF SITES

Having contacted the organizations listed above and having focused the investigation on Superfund sites and DoD/DOE facilities, Alliance selected for follow-up all those sites where contacts appeared to have reasonably substantial remedial performance data. The primary technologies identified were: ground water extraction and treatment; incineration; soil gas vacuum extraction; and bioremediation. The short list of sites which we attempted to explore in depth totaled twenty.

Following the initial telephone contacts, Alliance mailed letters to each of the project managers responsible for these twenty sites. The letters listed the detailed information requested, and noted the objectives of EPA. Subsequent telephone calls were made to discuss individual sites and request additional data. Section 3 addresses many of the issues associated with data collection, highlighting some significant problems in the tracking of site remediation data. Table 1 is an index of the sites for which information was requested.

TABLE 1. INDEX OF SITES FOR WHICH ALLIANCE SOLICITED PERFORMANCE AND COST DATA

SITE NAME	REGION	STATE	REMEDIAL TECHNOLOGY
Chem-Dyne	5	OH	Ground Water Extraction and Granular Activated Carbon Treatment
Commencement Bay	10	WA	Ground Water Extraction and 2-Step Granular Activated Carbon Treatment
Des Moines	7	IA	Ground Water Extraction and Air Stripping
Eau Claire	5	WI	Ground Water Extraction and Air Stripping
Newport Dump	4	KY	Sanitary Landfill; Gas and Leachate Collection
Old Inger	6	LA	Bioremediation (pilot)
Ponders Corner	10	WA	Ground Water Extraction and Air Stripping; Soil Vapor Extraction
Reilly Tar	5	MN	Ground Water Extraction and Carbon Filter
Sylvester's	1	NH	Slurry Wall and Cap; Ground Water Extraction; Physical, Chemical, and Biological Treatment
Twin City	5	MN	Ground Water Boundary Recovery System; In-situ Volatilization
United Chrome	10	OR	Ground Water Extraction and Air Stripping
Verona Well	5	MI	Carbon Filtration; Soil Gas Vacuum Extraction
Waverly	7	NB	Ground Water Extraction and Air Stripping; Soil Vapor Extraction
Western Processing	10	WA	Ground Water Extraction and Air Stripping
Cornhusker (Fed. Fac.)	7	NB	Transportable Incineration Unit
Eglin AFB (Fed. Fac.)	4	FL	Enhanced In-situ Bioremediation
McClellan AFB (Fed. Fac.)	9	CA	Ground Water Extraction; Incineration; Biodegradation
Rocky Mountain Arsenal (Fed. Fac.)	8	CO	Ground Water Extraction and Treatment
Sharp Army Depot (Fed. Fac.)	9	CA	Ground Water Extraction and Granular Activated Carbon Treatment
Wurtsmith (Fed. Fac.)	5	MI	Ground Water Extraction and Air Stripping; Incineration

CASE STUDY FORMAT

An outline was prepared for presentation of the case studies, consisting of the following five sections: (1) Introduction, (2) Background and Description, (3) Process Description, (4) Performance and Operational Data and (5) Cost Data. The introduction summarizes the major elements of the other sections and refers to the treatment technology employed, contaminants existing onsite, operating duration of the treatment systems, and actual costs incurred. The background section provides information on relevant events preceding the installation of the selected treatment technology. Topics include historical land use, volumes of contaminated materials, remedial investigation and feasibility study results, and the chosen remedial method. The process description section details flow schematics, design parameters, and the basic theory of the utilized treatment technology. Whenever possible, a process flow chart is also included.

The operational and performance data sections identify process parameters, operating schedules, volumes of material treated, and duration of system operation. Also included, whenever possible, are contaminant concentrations before and after treatment and associated removal efficiencies.

Capital and O & M costs are presented in the cost section. Both estimated and actual costs are itemized, when available. The cost section focuses on expenses incurred for design, construction, and operation of the site treatment systems. Discrepancies between estimated and actual costs are explained, if possible.

SECTION 3
ISSUES ASSOCIATED WITH DATA COLLECTION

Alliance contacted a variety of individuals and organizations to access performance and cost data for operating hazardous waste treatment technologies. Because of uncertainties regarding the extent and type of data available based on our information screening efforts, it was considered most cost effective to solicit the available technical information by telephone and assess its value rather than mount an extensive traveling campaign of unpredictable cost effectiveness. The information provided by our sources via Alliance's telephone requests was so varied and seemingly difficult for our contacts to access that it became apparent that most technology managers had no formalized management system for collecting, organizing, and accessing relevant performance and cost data.

PARTIES THAT PROVIDED DATA

Alliance received performance and cost data applicable to the sites with ongoing or completed remedial actions listed in Table 2. Organizational sources of information included the EPA regions, DoD, city representatives, the Corps of Engineers (COE), consulting firms, and in one case, the State of Washington Department of Energy. Although we had expected the COE, for instance, to be a major source of comprehensive cost information for all EPA related sites, this did not prove to be the case. The EPA regional project managers (RPMs) provided most of the information received by Alliance, but the variability associated with the data received from case to case was indicative of the lack of a formal Agency-wide data management system. In one case where a local government body had a role in management of remedial operations, their representative provided facility cost data. In another case, an employee of a private consulting firm provided information. In total, we received data relevant to 13 of the 20 sites of interest from the sources noted. Of these 13, nine included sufficient data to develop cases, as presented in Appendices A through I.

PROBLEMS IN ACCESSING DATA

None of the cases include detailed, actual capital and operating cost breakdowns to the extent that one would include in an engineering estimate. Some of the cases do include detailed estimates (e.g., ROD estimates and design estimates), but once projects are implemented, we found that detailed costs are not routinely tracked. Consequently, the cost information of most importance to case analysis, detailed, categorical capital and operating costs, are subject to a considerable degree of case specific variability.

TABLE 2. INDEX OF PERFORMANCE AND COST DATA RECEIVED BY ALLIANCE

Site Name	EPA Reg	State	Remediation Technology	Contact(s)	Fund/PRP/DOD
Cornhusker (Federal Facility)	7	NB	Transportable Incineration Unit	Bob Turkeltaub (Project Mgr)	DoD
Des Moines	7	IA	GW Extraction & Air Stripping	Glen Curtis (RPM) 913-236-2856	Fund
Eau Claire	5	WI	GW Extraction and Air Stripping	Fran Allens (RPM) 312-353-6261 Sam Spanel (City) 715-839-4920 Doug Baird (COE) 612-437-8264	Fund
Eglin AFB (Federal Facility)	4	FL	Enhanced In-Situ Bioremediation	Doug Downey (Sr. Engr)	DoD
McClellan AFB (Federal Facility)	9	CA	GW Extraction; Incin.; & Biodegradation	Doug Mackenzie (Project Engr) Doug Mackenzie, 916-643-1250 Mario Ierardi (Project Mgr)	DoD
Newport Dump[a]	4	KY	Sanitary Landfill; Gas & Leachate Collection	Mary Jo Penick (RPM) 404-347-7791	Fund
Ponders Corner	10	WA	GW Extraction & Air Stripping; Soil Vapor Extraction	Janet O'Hara (RPM) 206-442-2712 Bob Forster (City) 206-588-4423	Fund & City of Lakewood Water District
Rielly Tar[a]	5	MN	GW Extraction & Carbon Filter	Dave Wilson (RPM) 312-353-9223 Justin Blum (State) 612-296-7706 James Grube (City) 612-924-2551	PRP with State Oversight
Sylvester's	1	NH	Slurry Wall & Cap GW Extract. & Trtmt	Chet Janowski (RPM) 617-573-9623	Fund Lead State Lead
South Tacoma[a] Commencement Bay	10	WA	GW Extraction & GAC	Kevin Rochlin (RPM) 206-442-2106 Renee Fuentes (EPA) 206-442-1599 Mark Snyder (B&V) 206-992-3857 Steve Rossignoi (COE) 206-764-3461 Bill McFarlane (EPA Reg 7) 816-426-5805	Fund
Twin City, New Brighton, NH[a]	5	MN	GW Boundary Recovery	Arthur Klienrath (RPM)Fund/Army RP	
United Chrome	10	OR	GW Extraction & Chemical Treatment	Lauren McPhillips (RPM) 206-442-4903 Randy Pratt (CH2M Hill) 503-752-4271	Fund/Corvallis
Western Processing	10	WA	GW Extraction & Air Stripping	Lauren McPhillips (RPM) 206-442-4903 Wayne Grother (EPA) 206-442-1993	PRP/Boeing Lead

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a. Insufficient data for case development

DATA RELIABILITY AND COMPLETENESS

Confidence limits were infrequently specified for estimated costs and quality specifications were not available for any of the actual cost information. Likewise, the quality of technology performance data was rarely specified in the documentation reviewed. Consequently, extrapolation of the case information in a general fashion or to other sites should be done with caution, if at all.

Alliance attempted to calculate present-worth unit remediation costs in terms of $ per gallon of water treated or $ per cubic yard of soil treated for all cases. Unfortunately, the resulting costs varied over a range of 4 or 5 orders of magnitude, providing further evidence of the lack of commonality and comprehensiveness in all of the case information provided. We know that in some cases, all costs were not accounted for, but these results suggest that other costs of an unknown nature also are not being tracked.

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations presented in this section focus primarily on addressing the underlying difficulties associated with locating, accessing, and interpreting performance data currently being generated as a result of Superfund Remedial Actions. Neither Alliance nor EPA had anticipated the degree of difficulty that was ultimately associated with obtaining site specific performance data. Although only nine case studies were prepared presenting a comprehensive analysis of technical and cost data, the investigative process provided a mechanism to characterize many of the underlying causes for the lack of comprehensive quality data. Both technical and administrative problems were identified which need to be addressed by EPA. The increasing number of hazardous waste sites approaching the remedial phase accentuate the need for concise directives regarding the reporting, storage, and retrieval of performance data.

A number of the specific recommendations made below build on systems currently operational or in the development phase at EPA, namely, the Alternative Treatment Technology Information Center (ATTIC). Because one of the primary causes of difficulty encountered during the data gathering phase of this project was the variation in reporting of performance data, the need for Agency-wide systems and programs which facilitate data consistency is very important. It will be necessary for EPA to engage in technology transfer to the regions to optimize the utility of these systems.

The Superfund 90-day study (A Management Review of the Superfund Program, undated) provides a framework for the overriding recommendation included in this report to develop and use a standard system for storage and retrieval of performance and cost data relevant to operating remedial hazardous waste treatment technologies at Superfund sites. In essence, the report states that the Agency must provide for "extensive technical assistance, expert advice, and information transfer" for successful operation of the Superfund Program.

The 90-day study points out that uncertainties exist regarding the performance and cost of hazardous waste treatment technologies among EPA and responsible parties and that this situation raises difficulties in deciding among possible remedial actions and selecting the cost effective alternative. The study points out that such information is not being collected and distributed on an organized basis. Development of an information clearinghouse is recommended so that "all participants...can...'[play] from the same deck' of information". The report indicates that the Regions have taken steps to reduce inconsistency in decision-making but further steps are recommended including methodical distribution and updating of Headquarters guidances, establishment of nationwide technology support teams, and active communication between the "Office of Emergency and Remedial Response (OERR) ....[and].... the Regions to provide national consistency on procedures for selection of treatment technologies". The report indicates that Regional office peer reviewers could benefit from access to information on nationwide remedy-selection decisions. The report touches on other details, including the need to keep the ROD database updated, that RPMs should routinely review the ROD database, and that guidances should emphasize waste treatment. Finally, the report recommends that the SITE program should incorporate the means to record performance and cost data for technologies used at Superfund sites and that ORD should sponsor a group to develop a priority list of needed research. Development of such a priority list would be best achieved with the availability of an organized information storage and transfer system, as alluded to by the authors and as recommended herein.

Thus, EPA has established a clear mandate that Superfund technology performance and cost data must be evaluated and compiled and made easily accessible to decision-makers. ORD has initiated a clearinghouse called the Alternative Treatment Technology Information Center (ATTIC) to provide access to known available reference sources that include treatment technology data. The ATTIC system should be used as the basic mechanism for storage and retrieval of performance and cost data for remedial technologies in use at Superfund sites. Further, EPA should conduct site visits and engineering evaluations at Superfund sites to document technology performance and cost.

Bulleted conclusions and recommendations follow.

CONCLUSIONS

- With the exception of a few localized regional efforts, there is no apparent existing mechanism, either at EPA, DOD, the COE, or elsewhere, for the routine, pre-planned cataloging of performance and cost data relevant to operating, full-scale treatment technologies used at hazardous waste sites/facilities.

- The type, quantity, and specificity of available performance and cost data relative to hazardous waste site clean-up efforts varies, unconstrained by any formal directives or guides for data management.

- Available performance and cost data are of unknown accuracy and validity. Furthermore, much of the recorded information is incomplete.

- Because available performance data are inconsistent and incomplete with respect to existing full scale installations, evaluations of planned technologies cannot be adequately based on past experience at Superfund sites. This makes it difficult for RPM's to compare among alternative technologies and to select the best technology for a given application.

- It is conceivable that Superfund site responsible parties maintain thorough cost records, but they are not required to make the information available and, therefore, are unwilling to provide the information.

- As more sites enter the remedial action phase, both under the RCRA and CERCLA programs, it is becoming clear that data interpretation is a significant task. EPA needs to recognize the magnitude of this task at the regional level and provide support for regional personnel, both by way of guidance and incentives for remaining on top of a rapidly increasing amount of performance data.

RECOMMENDATIONS

- In concert with EPA's new ATTIC system, EPA should establish a program for recording, storing, and retrieving performance and cost data relevant to operating, full-scale treatment technologies used at hazardous waste sites, and in particular, Superfund sites.

- A standard set of criteria for recording performance data must be formulated. While the initiation of such a system across all of EPA's Remedial Programs is a significant task, it is the only solution which will effectively yield usable remedial data (both technical and cost), and thereby optimize the selection and implementation of alternative treatment technologies.

- EPA should establish a format guide that regional personnel could use to catalog performance and cost data into standard formats for subsequent input to ATTIC. The quality of all data should be defined, and if unknown, it should be so stated.

- EPA should publicize and require the use of a format guide. A time limit or other suitable performance measure should be established for storing these data in the ATTIC system.

- EPA should investigate the viability of requiring PRP's to record treatment technology and cost data in an appropriate format for input to ATTIC, thus, eliminating the need to "translate" data prior to input.

- Although there are, as yet, no standard procedures for recording, storing, and retrieving performance data throughout EPA's remedial programs, the need for consistent data to evaluate site remediation plans has given rise to a few localized regional efforts. EPA should evaluate the effectiveness of such existing systems, and their compatibility with ORD's ATTIC system, to avoid duplication of effort and unnecessary change.

- The managers of EPA's ATTIC database management system should establish the necessary computer code to allow for storage and retrieval of treatment technology performance and cost data.

- EPA should evaluate and identify the best existing personnel in the regions to acquire, reformat as necessary, and log performance and cost data.

- EPA should proceed as rapidly as possible to finalize and secure the appropriate authorizations for the implementation of an Agency-wide remedial technology database for storage in a system such as ATTIC. With an increasing number of sites (both RCRA and CERCLA) implementing treatment technologies or approaching the remedial phase, consistent criteria should be agreed upon and applied now. Delays in implementation will require considerable effort to evaluate incompatible data sets, and will undoubtedly alienate EPA personnel who have, through necessity, developed their own systems to monitor site remediations.

- The appended case studies should be augmented through field visits and office visits to collect as much relevant data as there are available and to allow for independent engineering evaluations of technology performance and cost. Similarly, future data collection efforts to assemble case studies of this kind should be designed to rely on field visits and associated engineering evaluations. As part of EPA's Municipal Construction Grants Program, the Agency pursued a similar course of action to document the performance and cost of alternative wastewater treatment technologies. The resulting Innovative and Alternative Technology Program Field Report was considered to be a valuable resource in the implementation of EPA's municipal wastewater treatment program.

APPENDIX A

CORNHUSKER ARMY AMMUNITION PLANT

Case Study of Incineration of Explosives-Contaminated Soil

DISCLAIMER

This case study was prepared based on data provided to Alliance Technologies Corporation by various sources. Alliance recognizes that significant data gaps and inconsistencies may exist in the case study because the degree of data quality and completeness could not be defined.

Introduction

Explosives manufacturing operations at the Cornhusker Army Ammunition Plant resulted in the contamination of approximately 9.5 billion gallons of ground water with explosive compounds from cesspools and leaching pits located on the plant site. No remedial action was conducted to decontaminate the ground water; instead, the Army extended the City water supply system to provide service to areas affected by the contamination. Remediation at this national priorities list site was implemented by International Technology Corporation (IT) for the cleanup of an estimated 22,000 tons of explosives-contaminated soil. The primary treatment technology utilized was a soil incineration process referred to as the Hybrid Thermal Treatment System (HHTS) which was chosen due to its demonstrated effectiveness in the destruction of explosives-containing soils. Incineration operations were completed on July 20, 1988 after 40,000 tons of soil had been processed. Costs for post planning and trial burn operations totaled $230/ton of material incinerated.

Site Description and Background

The Cornhusker Army Ammunition Plant is a 12,000 acre site located in Hall County, Nebraska, two miles west of the City of Grand Island (figure 1). This Government Owned-Contractor Operated location served as a load, assemble, and pack (LAP) facility for explosives during World War II, the Korean Conflict, and the Vietnam Conflict. Facilities consist of five major LAP production areas, an ammonium nitrate area where fertilizer was produced, storage facilities, a sanitary landfill, and a burning ground for open burning of explosives contaminated material. Munitions operations at the site have been in standby status since 1973, although maintenance activity continues. The operating contractor is Mason & Hanger Silas Mason (MHSM).

Previous operations at the facility resulted in generation of explosives-contaminated wastewaters which were discharged into 48 cesspools and 10 leaching pits located on the site. Ground water contamination originating from these wastewater impoundments has migrated approximately 3 1/2 miles off the Cornhusker site and into drinking water wells in a residential area of Grand Island. Primary contaminants detected in the ground water are trinitrotoluene (TNT) and cyclotrimethylenetrinitramine (RDX).

Remediation of the wastewater impoundments was required to prevent further ground water contamination in the area. No remediation was implemented for the estimated 9 1/2 billion gallons of contaminated ground water. The Army provided for an extension of the Grand Island water supply system into those areas with contaminated drinking water.

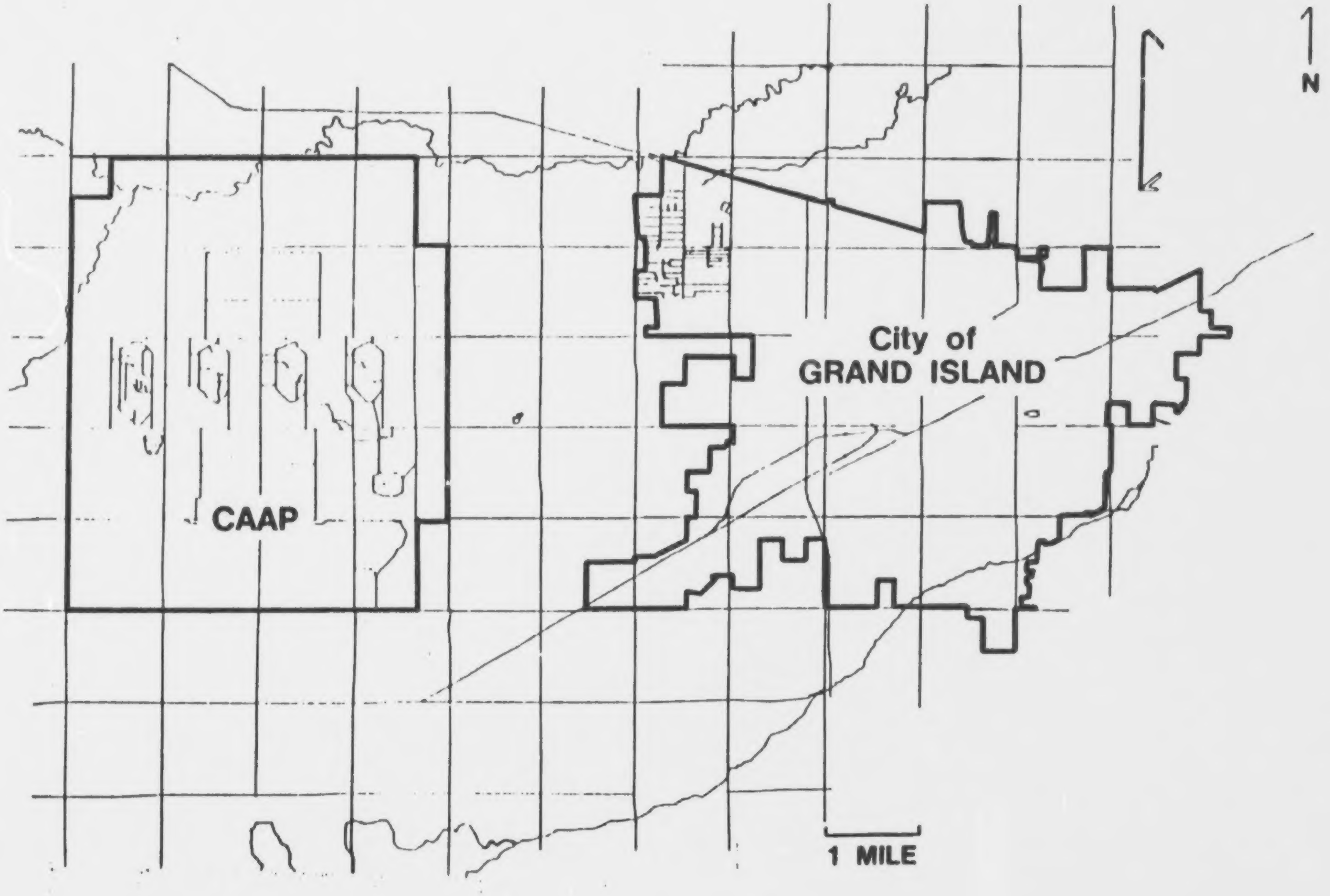
N
City of
GRAND ISLAND
CAAP
1 MILE

Figure 1. Cornhusker Army Ammunition Plant and Grand Island.[1]

In September of 1986, the MHSM Company was required to begin preliminary cleanup operations consisting of construction of a concrete storage pad to hold contaminated soil, sampling and analysis of wastewater impoundments, excavation of contaminated soil, open burning of contaminated bricks and pipe, and installation of roads, utilities, and drainage for the cleanup. The Army implemented its authority for remedial operations under CERCLA/SARA with the lead agency being the Nebraska Department of Environmental Control (NDEC). A Memorandum of Agreement was signed with the NDEC in April of 1987 and IT Corporation was awarded a service contract to implement soil incineration operations. The site was added to the National Priorities list in June of 1987.

Process Description

The incineration system utilized by IT Corporation is referred to as the Hybrid Thermal Treatment System (HTTS) and can process up to 26 tons of explosives-contaminated soil per hour. A flow diagram for the system is provided in Figure 2. Soil is fed through a classifier and shredder before being transported via belt conveyer to a countercurrent rotary kiln. Vaporization and destruction of explosive contaminants occurs within the kiln. Additional contaminant destruction occurs with a vertical downfired secondary combustion chamber.

Gases are cooled through a wet quench before being treated in a gas scrubbing air pollution control system to neutralize acid gases and remove entrained particles. The scrubber water is processed through a wastewater treatment system to remove suspended solids and adjust pH. This treated water is mixed with the hot ash discharged from the kiln to provide cooling and dust control. Safe operation is assured through a comprehensive interlock control system which allows material to be fed into the process only when all key operating conditions are maintained. The layout of the HTTS operating site is presented in Figure 3.

Operational Data

Operating limits for the HTTS were established through evaluation of results achieved during a test burn conducted on October 7-9, 1987. While trinitrobenzene (TNB) was the original principal organic hazardous constituent designated for the test burn, concentrations of this contaminant were too low to prove a destruction and removal efficiency of 99.99 percent. As a result, TNT was used as a substitute principal organic hazardous constituent. The established operating limits are presented in Table 1. The process was operated at a reduced rate of 15 tons per hour until these operating limits were determined.

Performance Data

Performance requirements for the system included a destruction and removal efficiency (DRE) of 99.99 percent for the principal organic hazardous constituent, HCL emissions less than 4 lb/hr and particulate emissions less than 0.08 gr/dscf. These limits were met during the test burn with a TNT concentration in the material feed ranging from 3,200 to 5,400 ug/g. Test burn results are presented in Table 2.

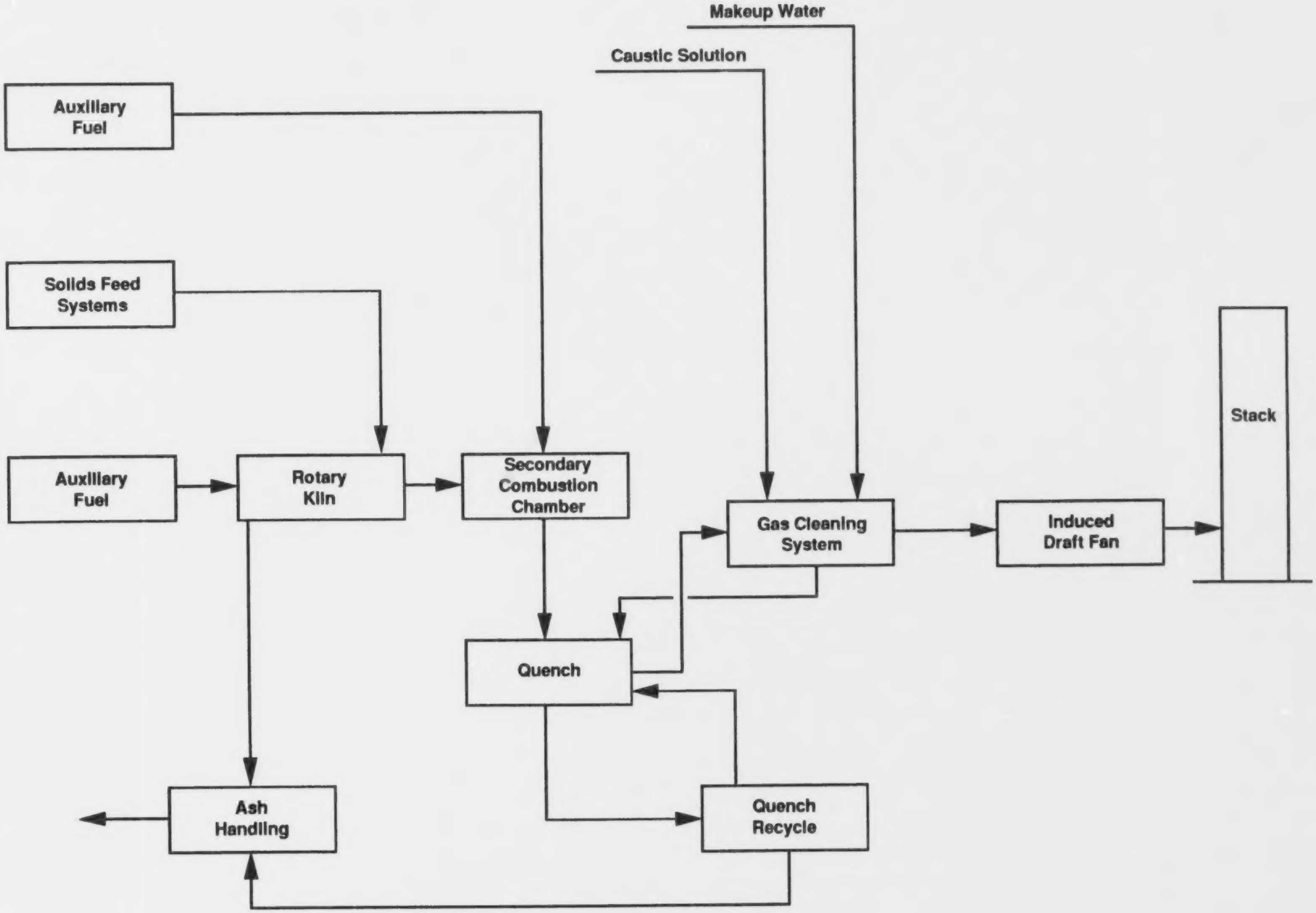
Makeup Water
Caustic Solution
Auxiliary Fuel
Solids Feed Systems
Auxiliary Fuel
Rotary Kiln
Secondary Combustion Chamber
Gas Cleaning System
Induced Draft Fan
Stack
Quench
Ash Handling
Quench Recycle

Figure 2. Hybrid Thermal Treatment System (HTTS) flow diagram.

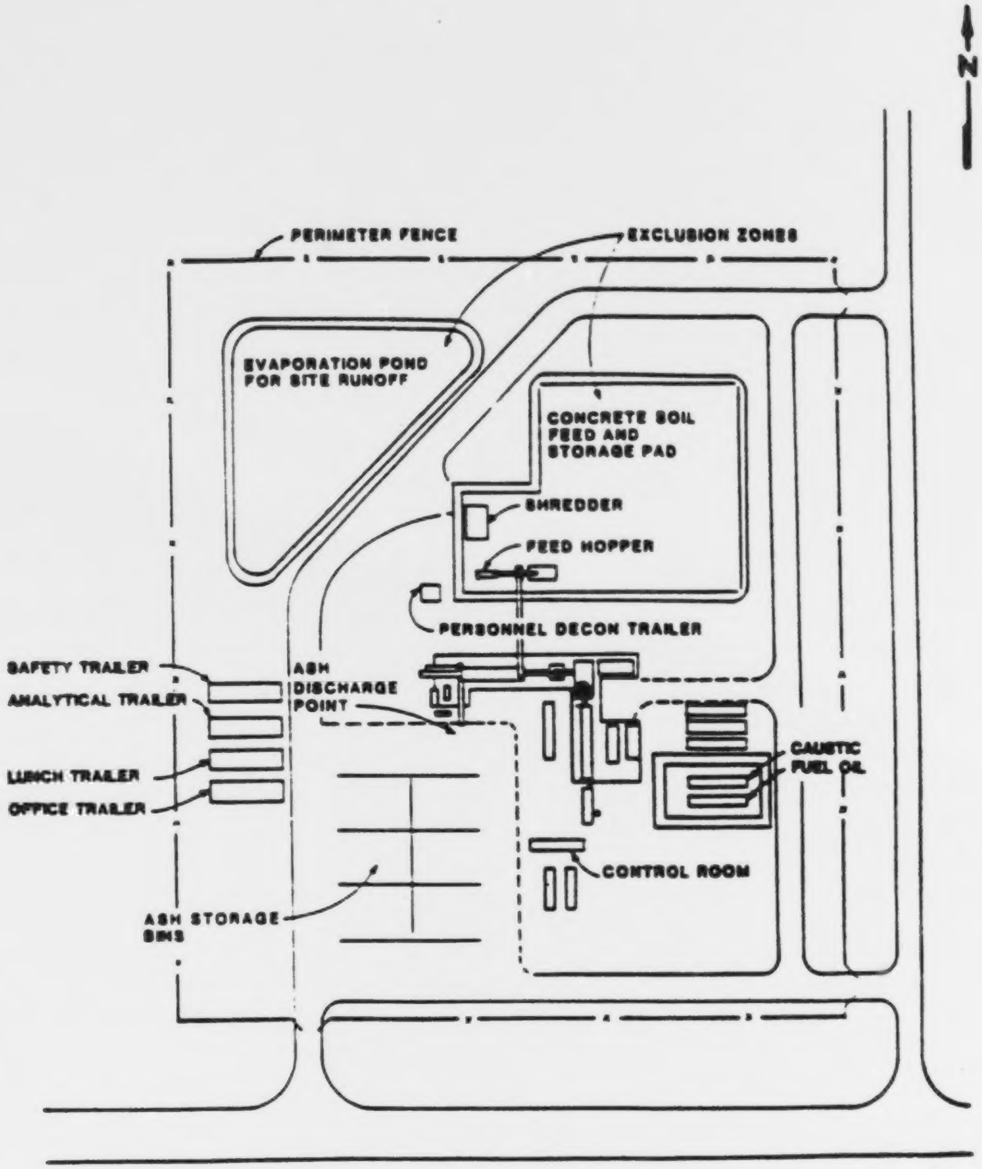
N
PERIMETER FENCE
EXCLUSION ZONES
EVAPORATION POND FOR SITE RUNOFF
CONCRETE SOIL FEED AND STORAGE PAD
SHREDDER
FEED HOPPER
PERSONNEL DECON TRAILER
SAFETY TRAILER
ANALYTICAL TRAILER
ASH DISCHARGE POINT
LUNCH TRAILER
OFFICE TRAILER
CAUSTIC
FUEL OIL
CONTROL ROOM
ASH STORAGE BINS

Figure 3. Hybrid thermal treatment system operating site.[1]

TABLE 1. HYBRID THERMAL TREATMENT SYSTEM OPERATING LIMITS[1]

Parameter/system	Operating/cutoff limit
Kiln solids feed rate (1-hour average)	26 tons per hour maximum
Kiln pressure (15 second time delay)	0.0 in. H_2O maximum
SCC combustion temperature (30 second time delay)	1500°F minimum
APC pressure drop (30 second time delay)	30 in. H_2O minimum
Carbon monoxide	
(10-minute average)	500 ppm maximum
(1-hour average)	100 ppm maximum
Stack gas velocity (10-minute average)	2800 ft/min maximum

TABLE 2. HYBRID THERMAL TREATMENT SYSTEM TEST BURN RESULTS[1]

Parameter	Run 1	Run 2	Run 2A	Run 3	Combined average	Units	Performance requirements
DRE, TNT	>99.999947	>99.999964	a	>99.999902	>99.999938	%	99.99%
HCl emissions	----	0.052	0.16	0.053	0.088	lb/hr	<4 lb/hr
Particulabe emissions	c	0.0009	0.0028	0.0013	0.0017	gr/dscf	<0.08 gr/dscf

[a] Destruction and removal efficiency was not determined for the Method 5 Run 2A..

[b] Corrected to 7% oxygen.

[c] Test Run 1 particulate and HCl data are not included because sampling train did not pass postsampling leak check. Run 2A was added to replace Run 1 for Method 5.

Problems were encountered with slag forming in the system at a kiln temperature of 1200°F. Clogging also occurred due to an excess amount of particulate matter being drawn through the secondary combustion chamber. These problems were resolved through use of a lower kiln temperature, some system modifications, and more intensive maintenance.

Incineration operations were halted from mid-October 1987 until February 1988 due to an industrial accident and the realization that the system required some winterization modifications. The incineration operation was completed on July 20, 1988. Processing of a total of 40,000 tons of explosives-contaminated soil through the HTTS resulted in the generation of approximately 2,400 tons of ash. The ash was disposed of on site by the MHSM Company after a determination that it was free of explosives and unacceptable levels of heavy metals.

Cost Data

The contract awarded to IT Corporation was a three phased service contract involving the Cornhusker site and another army installation. Phase I of the contract included planning for operations at the Cornhusker site on a cost plus fixed fee basis. Phase II of the contract called for incineration operations at the Cornhusker site on a unit price basis with schedule incentives. The third phase of the contract involved the other Army installation.

The bid schedule for Phase One at CAAP totaled $611,254 and included regulatory, permitting and lab certification costs. Phase Two costs included incineration, sampling and analyses, trial burn runs, and incentives costs. Phase Two cost estimates amounted to $3,697,448. Therefore, the total bid estimate for soil incineration at CAAP was $4,308,702. Table 3 shows bid estimates for remedial action at CAAP.

While the Army's original bid package estimated that 22,000 tons of explosives-contaminated soil would be processed, approximately 40,000 tons of soil were actually treated. This extended the schedule and nearly doubled the amount of samples to be analyzed. As a result, the incineration segment of the operation, which was bid on a per unit basis, cost considerably more than anticipated. The cost of all post-planning/trial burn operations came in at approximately $9.3 million or $230 per ton. A list of unit costs per activity is presented in Table 4.

An unresolved cost issue has resulted from the unanticipated $200,000 winterization cost for the treatment system. International Technologies Corporation is attempting to settle with the government for this unexpected cost.

TABLE 3. BID SCHEDULE FOR REMEDIATION OF THE CORNHUSKER ARMY AMMUNITION PLANT

ITEM	COST ($)
Phase I	
Advance Planning	332,962
Regulatory & Permits	122,232
Laboratory Certification	156,060
Phase I Subtotal	611,254
Phase II	
Incineration ($130/ton, 22,0000 tons)	2,860,000
Sampling & Analysis	232,870
Trial Burn Runs	484,578
Incentive	120,000
Phase II Subtotal	3,697,448
TOTAL BID COST	4,308,702

TABLE 4. UNIT COST DATA FOR REMEDIATION OF THE CORNHUSKER ARMY AMMUNITION PLANT[3]

Full Scale Post Planning & Operation	\$230/ton
Incineration*	\$130/ton
Excavation of soil*	\$ 5/yd^3
Moving incinerator ash*	\$ 2/yd^3
Filling excavated site*	\$ 5/yd^3
Reseeding of site*	\$.08/ft^2
Analysis of ash*	
Explosives content	\$300/analysis (800 analyses)
Metals content	\$339/analysis (400 analyses)
Winterization	\$200,000 (\$5/ton)

* Included in overall unit cost of \$230/ton

REFERENCES

Information contained in this report was compiled from the following sources:

1. Turkeltaub, R.L. and Wiehl, C.D., U.S. Army Installation Restoration Incineration Program at Cornhusker and Louisiana Army Ammunition Plants, November 1988.

2. Wirth, Peter K., Installation Restoration Program, Cornhusker Army Ammunition Plant, Summary Remedial Investigation Feasibility Study, U.S. Army Toxic & Hazardous Materials Agency Report No. AMXTH-IR-86086, May 1986.

3. U.S. Army Toxic and Hazardous Materials Agency, Installation Restoration Division, Aberdeen Proving Ground, Maryland, Telephone discussions with staff of Alliance Technologies Corporation, February 1989.

APPENDIX B

DES MOINES TCE SITE

Case Study of Ground Water Extraction
With Air Stripping

DISCLAIMER

This case study was prepared based on data provided to Alliance Technologies Corporation by various sources. Alliance recognizes that significant data gaps and inconsistencies may exist in the case study because the degree of data quality and completeness could not be defined.

CASE SUMMARY OF THE DES MOINES TCE SITE

Introduction

The Des Moines TCE site remedial operations were initiated in December, 1987 to clean up VOC contaminated ground water. Air stripping was determined to be the cost effective treatment method for the removal of VOCs. The time for completion of the remedial action is estimated at ten years.

Capital costs incurred for the installation of the collection and treatment system equaled $1,752,845. While operation and maintenance costs were not available from the PRP, they were estimated by the RPM to be $60,000 for the first three months of operation.

Site Description and Background

The Des Moines TCE site is located southwest of Des Moines, Iowa along the Raccoon River. The site area is shown in figure 1. The Des Moines TCE site was discovered after trichloroethylene (TCE) was detected in the Des Moines public water supply. Upon further investigation, it was determined that the major source of contamination originated on the Dico Company, Inc. property. Dico had been using a TCE-containing solvent as a metal degreaser in the manufacturing of metal wheels and brakes. The resulting oily sludge from this process, which contained TCE, was disposed of on the company parking lot for dust control. This disposal practice was discontinued in 1979.

The Des Moines Water Works maintains an underground infiltration_gallery system near the site as a source of public water supply. The north extension of the gallery is located within the site area. Operation of the northern portion of the gallery causes contaminated ground water to flow into the gallery and, therefore, use of the north gallery has been discontinued.

In September, 1983, the Des Moines TCE site was added to the National Priorities List of uncontrolled hazardous waste sites. The U.S. EPA initiated a remedial investigation and feasibility study (RI/FS) of the site in 1984. From this study, it was found that the primary contaminants of concern were volatile organic compounds in the surrounding ground water and soils. The primary VOCs detected during sampling were TCE, trans-1,2-dichloroethene (DCE) and vinyl chloride. The RI/FS provided seven remedial action alternatives. In July 1986, a Record of Decision (ROD) was signed which selected a remedial action plan for protection of the public water supply.

The selected remedy consisted of: 1) the installation of a vertical barrier wall across the northern section of the Des Moines Water Works gallery, and 2) the construction of a collection and air stripping treatment system to remediate the contaminated ground water. There were no plans for soil excavation or flushing. Technical data obtained during the remedial design stage (e.g. ground water modeling) prompted changes in the selected remedy.

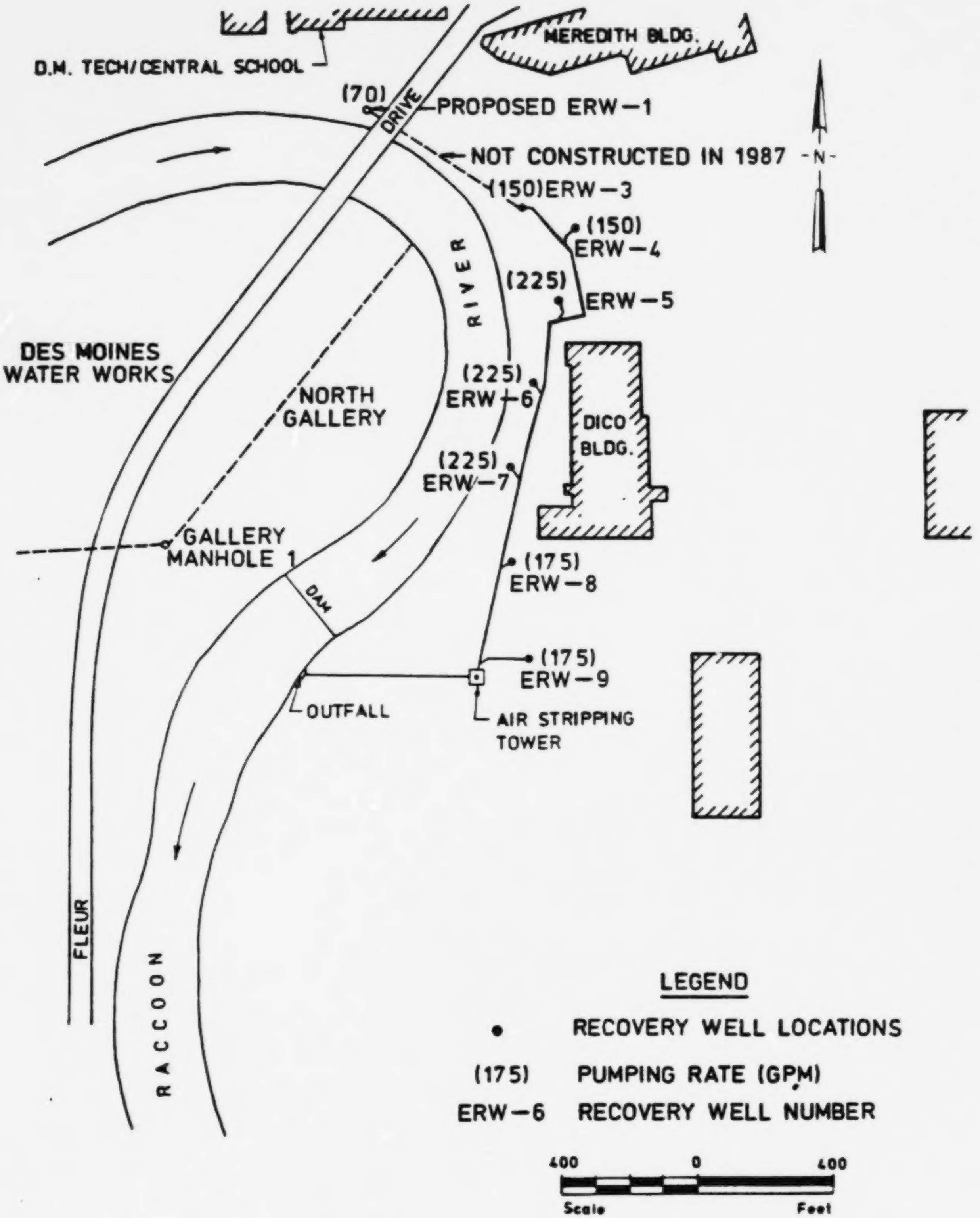
MEREDITH BLDG.
D.M. TECH/CENTRAL SCHOOL
(70)
DRIVE
PROPOSED ERW-1
NOT CONSTRUCTED IN 1987
-N-
(150)ERW-3
(150)
ERW-4
(225)
ERW-5
RIVER
DES MOINES
WATER WORKS
NORTH
GALLERY
(225)
ERW-6
DICO
BLDG.
(225)
ERW-7
GALLERY
MANHOLE 1
(175)
ERW-8
DAM
(175)
ERW-9
OUTFALL
AIR STRIPPING
TOWER
FLEUR
RACCOON
LEGEND
● RECOVERY WELL LOCATIONS
(175) PUMPING RATE (GPM)
ERW-6 RECOVERY WELL NUMBER
400
0
400
Scale
Feet

Figure 1. Des Moines TCE Site map and removal facilities location.

Reference: Veenstra and Kim, Operation and Maintenance Manual, TCE Removal Facilities, Dico Inc., Des Moines, Iowa, 1988)

The remedial action eventually implemented consisted of the following:

- isolation of the northern section of the Des Moines Water Works gallery near the TCE plume by the installation of mechanical packers within the gallery at the north and south outlets of manhole number one, which physically close off the northern portion from the remaining gallery system, and
- installation of a ground water extraction and treatment system utilizing an air stripper for the removal of VOCs from the extracted ground water.

Process Description

Seven ground water extraction wells are used to pump contaminated ground water to an air stripping tower, where it is treated and then discharged into the Raccoon River (figure 1). The design was intended to prevent contaminant movement toward the gallery and to effectively contain and capture the ground water plume.

Seven recovery wells, equipped with submersible pumps, transfer ground water to the air stripper tower. A flow diagram of the recovery system is shown in figure 2. The water is atomized upon entering the tower and cascades down through the packing material. Air is forced into the base of the tower and countercurrently contacts falling water droplets. The system provides for significant liquid-vapor interface and efficient VOC removal. The air strips the VOCs from the water and exits at the top of the tower. No emission controls are used. The treated water is discharged into the Raccoon River. Water samples taken from the Raccoon River and Des Moines River downstream from the discharge point have not indicated any VOC concentrations above the 1 ppb detection limit.

Operation Data

The air stripping column was designed for a flow rate of 1400 gpm with a range of 500 gpm to 1850 gpm. The design pumping rate for all recovery wells combined is 1325 gpm. Pumping of the recovery wells began on December 17, 1987. The actual average flow rate of the treatment system as of the end of the second quarter of 1988 was 1288 gpm. The total volume of contaminated water pumped to treatment at this point was 337,729,000 gallons.

Performance Data

The air stripper influent TCE concentration at start-up was approximately 2800 ppb. After 2 days, measurements indicate a drop to below 2500 ppb, and the TCE levels have gradually declined since then. After 5 months of operation, influent TCE concentrations leveled off to the range of 800 to 1000 ppb and remained fairly constant at that level through mid-November, 1988. The removal efficiency for TCE has been generally maintained above the 96 percent TCE removal design requirement established by EPA. Under optimum operating conditions, the TCE removal efficiency is 98 percent. During one period (August through mid-September, 1988), removal efficiencies dropped well below this level due to plugging of the filter media with iron precipitate. The air stripper returned to optimum operating conditions after subsequent cleanings. Removal efficiencies for trans-1, 2-DCE have been less consistent, but were generally in the 85 to

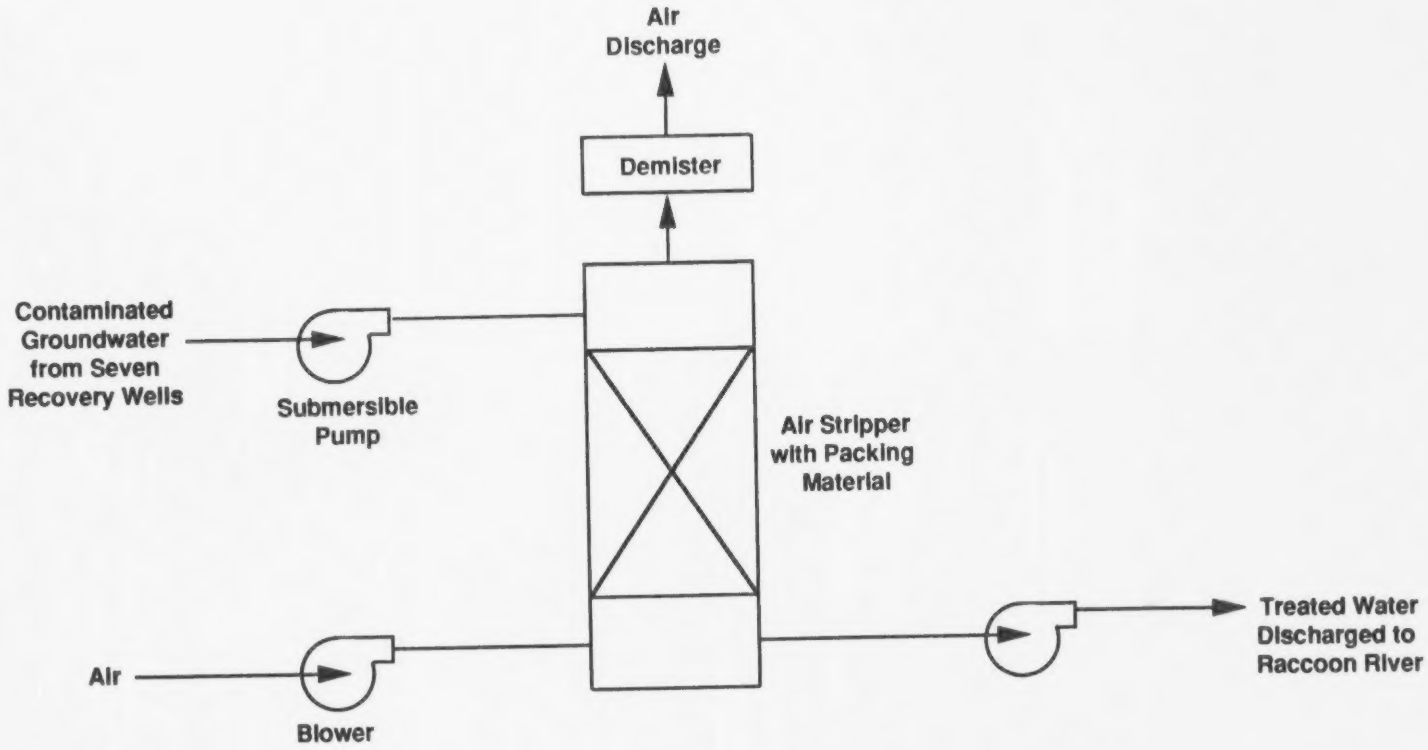
Air
Discharge
Demister
Contaminated
Groundwater
from Seven
Recovery Wells
Submersible
Pump
Air Stripper
with Packing
Material
Air
Blower
Treated Water
Discharged to
Raccoon River

Figure 2. Des Moines TCE Site remedial process flow diagram.

A89-143/A

96 percent range. With inlet concentrations of 38 to 1 ppb, there were no detectable levels of vinyl chloride in the treated effluent stream. Removal efficiencies are plotted in figure 3.

Cost Data

The capital costs from the ROD for the recommended alternative were estimated to total $1,196,000 with annual operation and maintenance costs amounting to $63,000. The 10-year present worth cost as estimated in the ROD amounted to $1,619,000.

Actual capital costs incurred at the Des Moines TCE site have been recorded by Dico for possible reimbursement due to evidence of a northern plume of contaminants that may not have resulted from the Dico operation. The total capital costs submitted as of May 29, 1988, equaled $1,752,845 and are listed in table 1. This figure includes legal fees of $177,343 and project fees of $438,236 which were not specifically itemized in the ROD estimate. Actual operating and maintenance costs were not available. The Remedial Project Manager estimated that Dico, Inc. has spent $60,000 for operation of the extraction and treatment system during the initial 3 months of operation.

The unit cost for ground water treatment is estimated to be about 0.045¢/gallon, assuming a 1250 gpm treatment rate and an annual average operation and maintenance cost of $200,000/year for ten years at 10 percent interest. The accuracy of this estimated unit cost is uncertain because of concerns noted in the case disclaimer and in the text of the main report regarding quality and completeness.

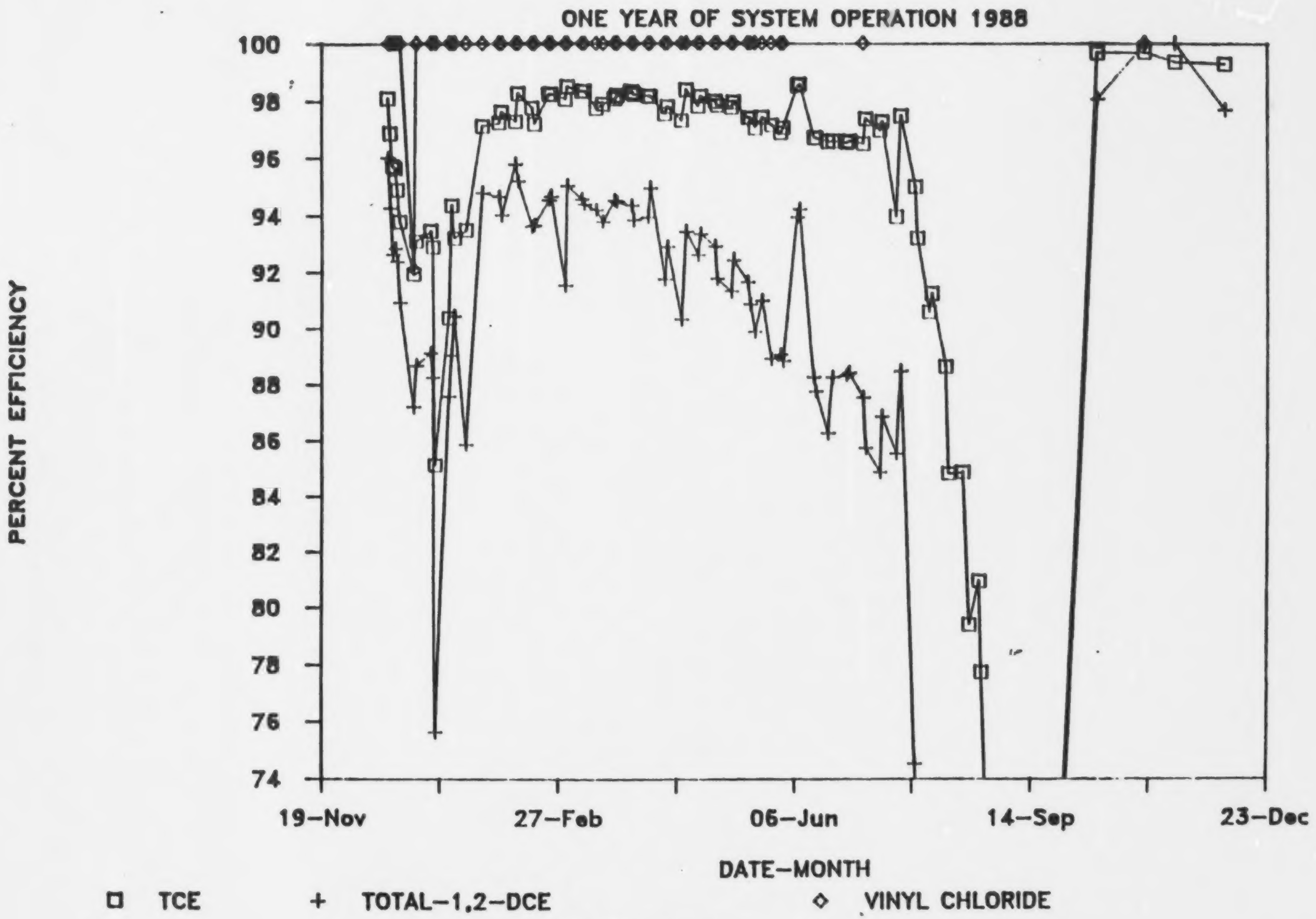

Figure 3. Air stripper efficiency.

Reference: Aware, Inc., presentation handouts of Performance Evaluation Report No. 3, Des Moines TCE Site, February 7, 1989.

TABLE 1. CAPITAL COSTS FOR THE DES MOINES TCE SITE

	Actual incurred cost [a]
DIRECT CAPITAL COSTS	
1. Overall Construction Costs	
a. equipment (total of item #2)	658,416[b]
b. additional labor	24,000
Subtotal	683,416
2. Equipment Costs	
a. installed equipment	595,180
b. purchased equipment	63,336
3. Land and Site Development	
a. equipment	3,267[c]
b. labor	2,838[d]
Subtotal	6,105
4. Buildings and Services	
a. equipment	
b. labor	
Subtotal	159,367[e]
5. Miscellaneous Costs	
Subtotal	4,073[f]
6. Disposal Costs	
Subtotal	-
TOTAL DIRECT COSTS	852,961

(continued)

TABLE 1. (Cont.)

	Actual incurred cost[a]
INDIRECT CAPITAL COSTS	
1. Engineering and Design	248,397
2. Project Management	438,236[g]
3. Other Indirect Costs	
a. legal fees	177,343
b. sampling and analysis	35,908[h]
Subtotal	213,251
TOTAL INDIRECT COSTS	899,884
TOTAL CAPITAL COSTS	1,752,845

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[a] Actual capital costs taken from "Petitioners Total Response Costs" as submitted by DICO, Inc. for reimbursement.

[b] Construction labor is for the installation of the air stripper only.

[c] Equipment costs for land and site development are for excavating and fencing and include installation fee.

[d] Labor costs for land and site development are for manhole modifications in the northern gallery.

[e] Building and services subtotal is for the equipment and installation of electrical services.

[f] Miscellaneous costs include unspecified costs or costs not falling into the listed categories.

[g] Includes project oversight, ground water modeling and performance evaluations.

[h] Sampling and analysis conducted during design and construction.

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2. Ecology and Environment, Inc. *Final Remedial Investigation Report*, Des Moines TCE Site. December 17, 1985.

3. Aware, Inc. *Performance Evaluation Report No. 1, Des Moines TCE Site Ground Water Recovery and Treatment System*. April 1988.

4. Aware, Inc. *Performance Evaluation Report No. 2, Des Moines TCE Site Ground Water Recovery and Treatment System*. August 1988.

5. Des Moines TCE Site. Presentation Handouts, Performance Evaluation Report No. 3. February 7, 1989.

6. U.S. EPA - Region 7. Des Moines TCE Site Fact Sheet. June 1988.

7. Veenstra and Kimm, Inc. *Operation and Maintenance Manual*, TCE Removal Facilities, Dico, Inc., Des Moines, Iowa, 1988.

8. U.S. EPA Region 7. Superfund Branch, Telephone Discussions, March 1989.

APPENDIX C

EAU CLAIRE MUNICIPAL WELL FIELD SITE

Case Study of Ground Water Extraction with Air Stripping

DISCLAIMER

This case study was prepared based on data provided to Alliance Technologies Corporation by various sources. Alliance recognizes that significant data gaps and inconsistencies may exist in the case study because the degree of data quality and completeness could not be defined.

CASE SUMMARY OF THE EAU CLAIRE MUNICIPAL WELL FIELD SITE

Introduction

Volatile organic compounds (VOCs) were detected in ground water extracted from the Eau Claire Municipal Well Field in March 1984. Remedial operations were initiated in August 1987, using air stripping treatment methods to remove VOCs from approximately 450 million cubic feet of contaminated ground water to provide a safe municipal drinking water supply. Ground water is currently extracted from municipal wells, but under the final remedial action, four new extraction wells will be installed in the two plumes of VOC contamination. Air stripping of contaminated well water using packed tower aeration was chosen as the preferred treatment method due to its proven ability to remove volatile organics effectively and its lower cost in comparison to other screened remedial technologies such as activated carbon treatment or steam stripping of the contaminated well water. Operation of the treatment system is expected to continue for at least five more years or perhaps longer until the cleanup of ground water is completed. Total capital costs for the installation of the air stripper treatment facility has totaled $1,511,557. Additional costs are expected when construction begins on the four new extraction wells. Costs for the first full calendar year of operation, 1988, amounted to $104,792. Of this total, $40,000 was an annual maintenance reserve grant for the repair/replacement of equipment.

Site Background and Description

The Eau Claire Municipal Well Field is located in northwest Eau Claire, Wisconsin, along the east bank of the Chippewa River. Figure 1 shows a map of the site area. The municipal well system supplies water to the residents and industries of the City of Eau Claire and the Township of Washington. Supply water is drawn from an alluvial sand and gravel aquifer which is considered the only isolated aquifer available to provide the City water demands in the Municipal Well Field area.

VOCs were detected in the municipal water supply by the Wisconsin Department of Natural Resources (WDNR) in March 1981, as part of a U.S. EPA ground water supply survey. In 1984, a Remedial Investigation and Feasibility Study (RI/FS) was initiated to further characterize the extent and level of contamination present. The site was listed on the National Priorities List in September 1985. A June 10, 1985, Record of Decision (ROD) issued by the EPA declared that the utilization of an air stripper would provide adequate protection of public health and welfare until the completion of the RI/FS and final remedy selection. This air stripper was placed on-line in August 1987.

Upon completion of the RI/FS, two separate plumes of ground water contamination with low levels of VOCs were identified (figure 1). Maximum concentrations of the most frequently detected VOCs in both plumes are listed below.

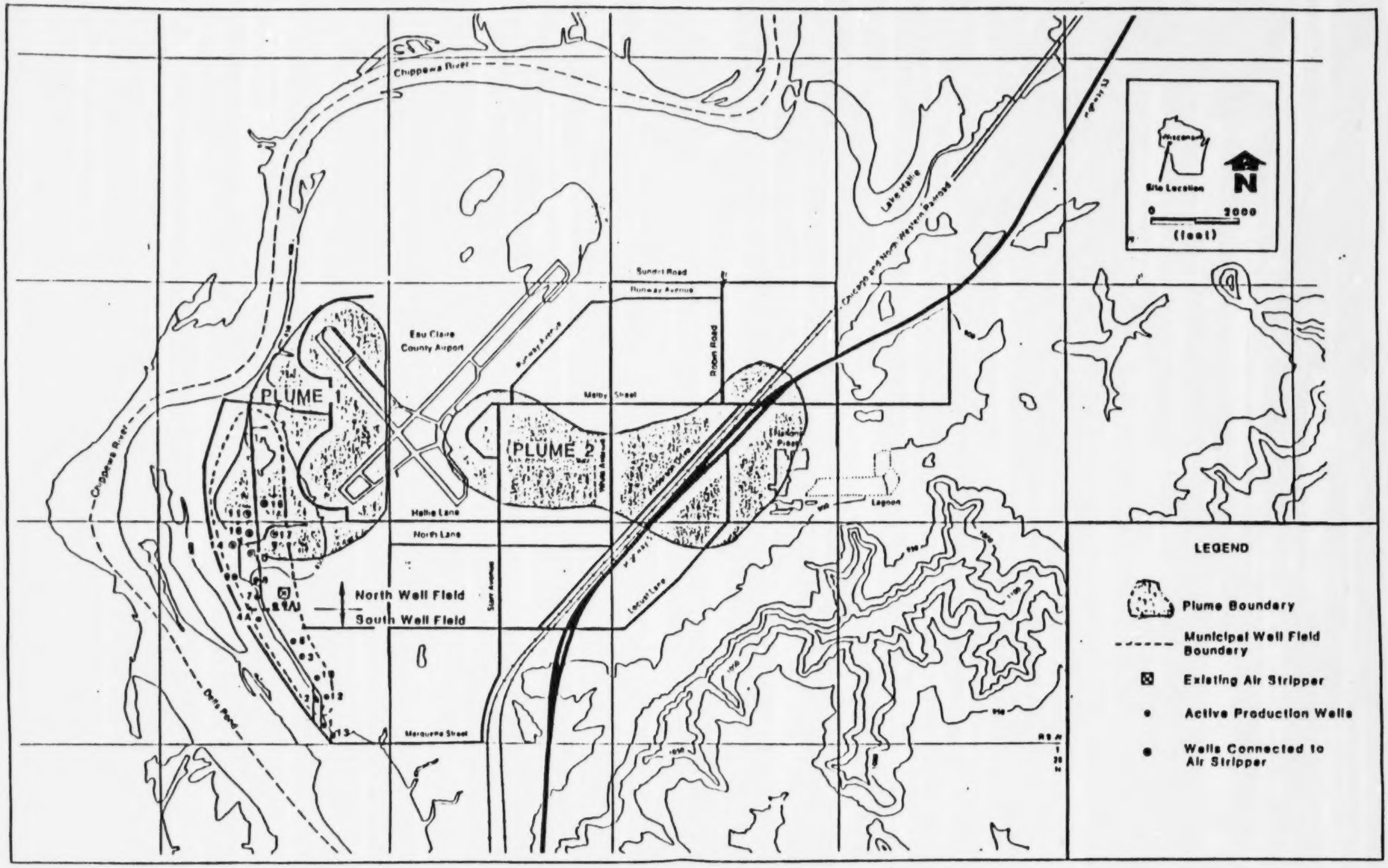
Chippewa River
Lake Hallie
Chicago and North Western Railroad
Sundet Road
Runway Avenue
Eau Claire County Airport
Robin Road
Melby Street
PLUME 1
PLUME 2
Hallie Lane
North Lane
North Well Field
South Well Field
Starr Avenue
Marquette Street
Locust Lane
Lagoon
Dells Pond
Site Location
N
0
2000
(feet)
LEGEND
Plume Boundary
Municipal Well Field Boundary
Existing Air Stripper
Active Production Wells
Wells Connected to Air Stripper

Figure 1. Eau Claire Municipal Well Field.

(Reference: U.S. EPA Decision Summary, Eau Claire Municipal Well Field Site, March 31, 1988.)

Contaminant		**Maximum Conc. (ppb)**
1,1,1-Trichloroethane	(TCA)	155
Trichloroethene	(TCE)	13
1,1-Dichloroethane	(1,1-DCA)	5
1,1-Dichloroethene	(1,1-DCE)	4
Tetrachloroethene	(PCE)	3

Plume 1 contains an estimated 190 million cubic feet of contaminated ground water. The estimated volume of contaminated ground water in Plume 2 is 260 million cubic feet.

During the RI, a source investigation was conducted to determine potentially responsible parties (PRP). The results of the investigation of several facilities did not confirm any potential sources of municipal well field contamination. However, National Presto Industries, a nearby NPL site, was not investigated during the RI/FS. An RI is currently in progress at the National Presto Industries site, and information from the study is expected to confirm or dispute whether National Presto Industries is the Eau Claire Municipal Well Field PRP.

Based on the evaluation of several alternatives given in the Feasibility Study, the U.S. EPA and the WDNR selected the final remediation plan. The main features of the selected plan are:

- Continue treatment of contaminated ground water with the existing air stripper;
- Provide municipal water to private well users;
- Install ground water extraction wells in plumes of contamination; and
- Discharge untreated ground water from extraction wells to the Chippewa River.

Process Description

As promulgated by the ROD, present remedial operations consist of air stripping treatment of contaminated ground water extracted from city wells at a maximum capacity of 11.2 million gallons per day (mgd). Treated water is discharged into the municipal water treatment facility for City drinking water supply. The air strippers were designed to achieve 99.3 percent removal efficiency for 1,1-DCE at a design concentration of 20 ppb (1,1-DCE was selected as the critical contaminant because it requires the most complete removal).

The air stripping facility maintains two packed towers. A cross section of a packed tower is shown in figure 2. When treatment of large flow rates is needed, the two strippers are operated together in parallel. Feed-water from the extraction wells is pumped to the top of the tower and distributed over the packing material. Air is forced into the base of the tower and makes contact with the cascading water droplets. VOCs are transferred from the contaminated ground water to the forced air stream, which passes through a mist eliminator and exits the top of the tower. The treated water is collected and pumped to the municipal water treatment system.

The final remedy selected in the ROD continued the use of the existing municipal wells and treatment system, and included plans for the installation of extraction wells. Four new extraction wells are to be installed within Plume 1 and Plume 2 to pump and discharge ground water into the Chippewa River without treatment. Treatment of ground water extracted from these wells was considered unnecessary because contaminant levels are below ambient water quality criteria (State and Federal standards). Only ground water extracted from the city wells is treated to maintain the City water demand.' Water consumers using private wells located in or near the plumes of contamination are to be connected to the municipal water system. The construction of the four extraction wells is to begin in September 1990 and connection of the private well users to the municipal system is expected to begin in September, 1989.

Operational Data

The air stripper treatment system has been in operation since August 1987. Lately, feed rates to the stripper have been between 5 to 6 mgd. The total volume of ground water treated was not available. The specific city wells used to provide system feed water vary; wells most often in operation are typically Nos. 11, 15, 16, and 17. The estimated time to implement and complete the selected final remedial action is 5 years.

Performance Data

Treatment system influent and effluent concentrations for 1,1-DCE, 1,1-DCA, TCA and TCE are shown in tables 1, 2, 3, and 4, respectively. VOC concentrations measured in the system influent vary depending upon which extraction wells are operated. 1,1-DCE inlet concentrations have generally been less than 2 ppb, well below the design concentration of 20 ppb. Although attainment of the 99.3 percent design removal efficiency for 1,1-DCE is difficult at these low influent concentration levels, the effluent is within Wisconsin regulatory requirements of 0.24 ppb and the target cleanup level of 0.10 ppb.

Cost Data

The estimated capital cost for the initial remedial action described in the ROD (construction of an air stripping treatment facility) equaled $1,420,000 with annual operation and maintenance expenses estimated at $195,000. Additional capital costs for implementation of the final remedy (four new extraction wells and provision of municipal water to private well users) were estimated at $1,214,000. This phase of the project is in progress.

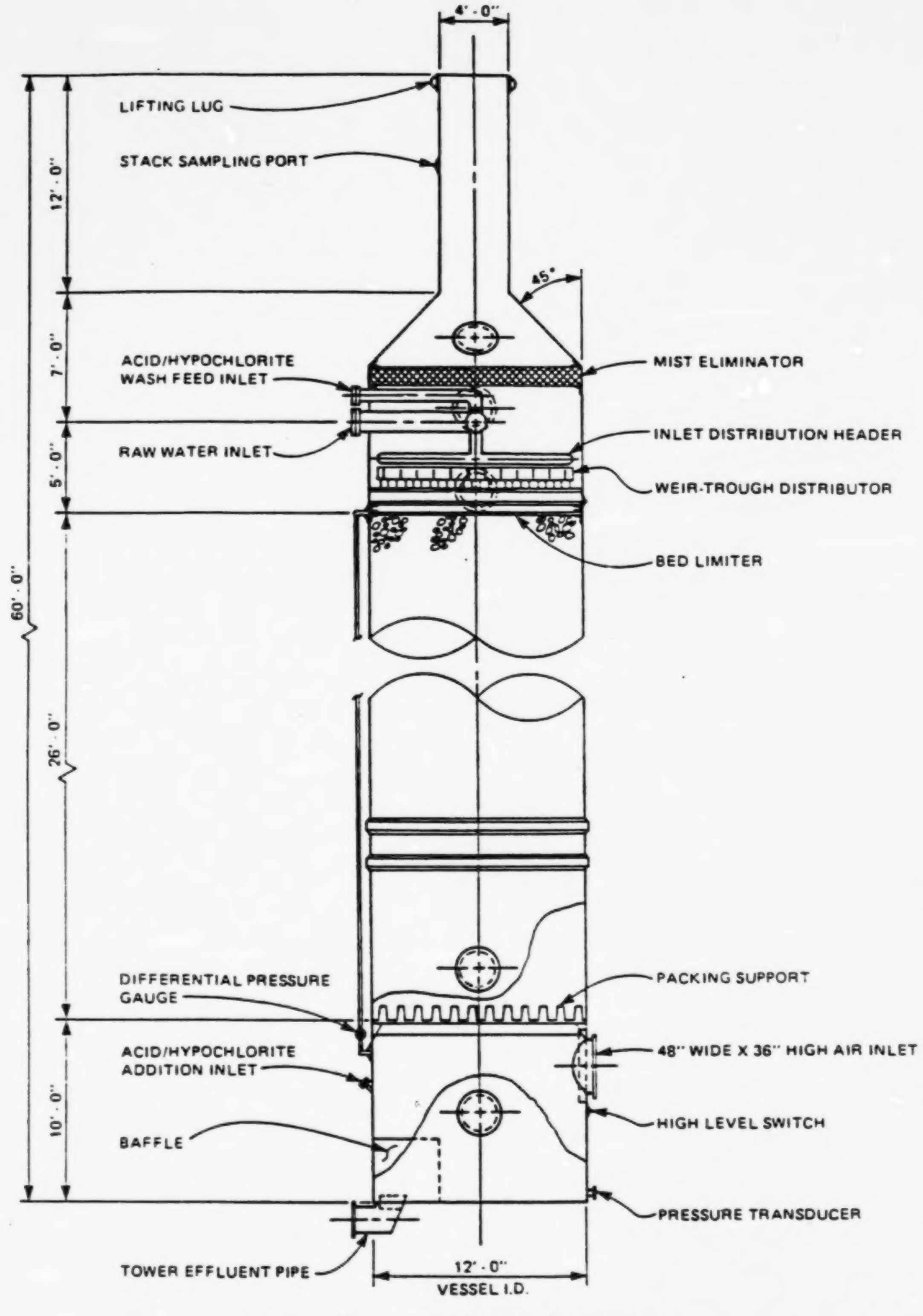
4' - 0"
LIFTING LUG
STACK SAMPLING PORT
12' - 0"
45°
7' - 0"
ACID/HYPOCHLORITE WASH FEED INLET
MIST ELIMINATOR
RAW WATER INLET
5' - 0"
INLET DISTRIBUTION HEADER
WEIR-TROUGH DISTRIBUTOR
BED LIMITER
60' - 0"
26' - 0"
DIFFERENTIAL PRESSURE GAUGE
PACKING SUPPORT
ACID/HYPOCHLORITE ADDITION INLET
48" WIDE X 36" HIGH AIR INLET
10' - 0"
HIGH LEVEL SWITCH
BAFFLE
PRESSURE TRANSDUCER
TOWER EFFLUENT PIPE
12' - 0"
VESSEL I.D.

Figure 2. Cross section of Eau Claire Packed Towers.

(Reference: CH_2M Hill, Operations and Maintenance Manual, Eau Claire Municipal Well Field Air Stripping Facility, October 1987.)

The project bid sheet for the construction of the facility totaled $1,139,153 with engineering and design costs of approximately $237,000, for a total capital cost of $1,376,153. The EPA, State, and the City of Eau Claire entered into an agreement by which 90 percent of operation and maintenance costs will be covered by EPA until cleanup levels are reached or for up to 10 years, whichever comes first. The remaining 10 percent will be paid by the State, and the City of Eau Claire will operate the ground water extraction and treatment facility. Therefore, bids were not solicited for operation of the air stripping facility.

The actual capital cost for completion of the air stripping facility was slightly higher than the bid due to several contract modifications. Changes included extra piping and wiring and the installation of a tower access ladder system. Actual capital costs totaled $1,511,557, including engineering and design costs as shown in table 5.

Because the new extraction wells have yet to be installed, no costs have been incurred for the final remedy. Operation and maintenance costs for the plant, as submitted by the City of Eau Claire for reimbursement, amounted to $104,792, which includes an equipment repair/replacement grant of $40,000 (see table 6). This amount is significantly lower than the estimated operational cost because administration, sampling and analysis, and ground water monitoring costs have not been reported as part of the project.

Assuming a five year operation period and an average treatment rate of seven million gallons per day, the unit cost of ground water treatment for the current process is estimated to be roughly 0.014¢/gallon. The accuracy of this estimated unit cost is uncertain because of concerns noted in the case disclaimer and in the text of the main report regarding data quality and completeness.

TABLE 1. TREATMENT SYSTEM INFLUENT AND EFFLUENT CONCENTRATIONS FOR 1,1-DCD*

Date	Influent (ppb)	Effluent (ppb)	Detection Limit (ppb)
08-31-87	1.24	ND	.03
09-08-87	0.18	ND	.03
09-14-87	1.24	ND	.03
09-21-87	1.28	ND	.10
09-28-87	1.26	ND	.10
10-05-87	1.24	ND	.07
11-02-87	0.93	ND	.07
12-08-87	0.71	ND	.05
01-05-88	1.43	ND	.03
02-09-88	1.35	ND	.06
03-31-88	1.42	ND	.04
04-04-88	1.21	ND	.04
05-23-88	0.49	ND	-
06-20-88	0.17	ND	.08
07-07-88	ND	ND	.38
08-15-88	1.56	ND	.13
09-12-88	2.78	0.17	.17
10-13-88	0.55	ND	.06
11-07-88	0.26	ND	.13
12-05-88	0.17	ND	.009
01-04-89	0.20	ND	.01
02-15-89	0.27	ND	.07

ND - Not Detected

*Source: Eau Claire Well Field Air Stripping Tower Data Sheets, submitted to EPA from the City of Eau Claire DPW, April, 1988.

TABLE 2. TREATMENT SYSTEM INFLUENT AND EFFLUENT CONCENTRATIONS FOR 1,1-DCA*

Date	Influent (ppb)	Effluent (ppb)	Detection Limit (ppb)
08-31-87	1.51	ND	.03
09-08-87	0.47	ND	.03
09-14-87	1.68	ND	.03
09-21-87	1.81	ND	.04
09-28-87	1.50	ND	.04
10-05-87	1.52	0.04	.03
11-02-87	1.50	ND	.04
12-08-87	1.04	ND	.02
01-05-88	1.45	ND	.01
02-09-88	1.77	0.11	.03
03-31-88	1.52	ND	.03
04-04-88	1.50	ND	.03
05-23-88	ND	ND	-
06-20-88	1.26	ND	.06
07-07-88	0.38	ND	.18
08-15-88	1.52	ND	.06
9-12-88	1.58	ND	.10
10-13-88	0.82	ND	.07
11-07-88	0.67	ND	.12
12-05-88	0.90	ND	.019
01-04-89	0.85	ND	.02
02-15-89	1.04	ND	.13

ND - Not Detected

*Source: Eau Claire Well Field Air Stripping Tower Data Sheets, submitted to EPA from the City of Eau Claire DPW, April, 1988.

TABLE 3. TREATMENT SYSTEM INFLUENT AND EFFLUENT CONCENTRATIONS FOR TCA*

Date	Influent (ppb)	Effluent (ppb)	Detection Limit (ppb)
08-31-87	12.81	.02	.02
09-08-87	8.02	ND	.02
09-14-87	13.20	.07	.02
09-21-87	13.00	ND	.04
09-28-87	11.04	ND	.04
10-05-87	11.53	ND	.02
11-02-87	8.75	.06	.04
12-08-87	6.60	.04	.02
01-05-88	10.09	.10	.01
02-09-88	11.66	.16	.02
03-31-88	8.71	.04	.02
04-04-88	10.76	.05	.02
05-23-88	7.73	ND	-
06-20-88	10.41	.22	.04
07-07-88	9.18	ND	.13
08-15-88	14.99	.04	.04
09-12-88	7.57	ND	.07
10-13-88	6.40	ND	.09
11-07-88	4.32	ND	.09
12-05-88	5.03	ND	.016
01-04-89	6.07	ND	.02
02-15-89	7.07	.38	.11

ND - Not Detected

*Source: Eau Claire Well Field Air Stripping Tower Data Sheets submitted to EPA from the City of Eau Claire DPW, April, 1988.

TABLE 4. TREATMENT SYSTEM INFLUENT AND EFFLUENT CONCENTRATIONS FOR TCE *

Date	Influent (ppb)	Effluent (ppb)	Detection Limit (ppb)
08-31-87	7.82	.05	.02
09-08-87	4.04	.07	.02
09-14-87	6.26	.03	.02
09-21-87	5.88	.04	.04
09-28-87	5.18	ND	.04
10-05-87	5.44	.02	.02
11-02-87	3.72	ND	.03
12-08-87	2.71	ND	.02
01-05-88	5.14	.12	.01
02-09-88	5.97	.20	.02
03-31-88	3.96	.04	.02
04-04-88	4.46	.04	.02
05-23-88	3.55	ND	-
06-20-88	4.85	.23	.04
07-07-88	5.19	ND	.12
08-15-88	11.18	.08	.04
09-12-88	4.37	.08	.07
10-13-88	2.53	ND	.06
11-07-88	2.82	ND	.09
12-05-88	2.71	ND	.014
01-04-89	3.47	ND	.02
02-15-89	3.38	.13	.10

ND - Not Detected

*Source: Eau Claire Well Field Air Stripping Tower Data Sheets, submitted to EPA from the City of Eau Claire DPW, April, 1988.

TABLE 5. CAPITAL COSTS[a]

Cost Component	Actual incurred cost ($)
DIRECT CAPITAL COSTS	
Overall Construction Costs	
a. installed equipment	946,184
b. additional labor	0
c. materials	0
Subtotal	946,184
Land and Site Development	98,340
Buildings and Services	230,003
Disposal Costs	0
Total Direct Costs	*1,274,558*
INDIRECT CAPITAL COSTS	
Engineering and Design	237,000[b]
Contingencies	-
Other Indirect Costs	NA
Total Indirect Costs	*237,000*
TOTAL CAPITAL COSTS	*1,511,557*[c]

NA = Not Available

[a] Actual cost based on Project Bid Schedule for the Eau Claire Municipal Well Field Air Stripping System and Contract Modifications P00001-P00022.

[b] Engineering and Design costs reportedly totaled $297,000 and also included costs for the site feasibility study. An actual cost of the FS was not available but was estimated at $60,000 by the EPA RPM.

[c] Capital Costs are for the initial remedy selection (installation of the air stripper) and do not include the final remedial actions such as the construction of the new extraction wells, which are currently underway.

TABLE 6. ANNUAL OPERATING COSTS

Cost component	Actual incurred cost[a] ($)
O&M COSTS	
Operating Labor	33,036
Maintenance materials and labor	0
Auxillary materials and labor	0
Lab Apparatus and Supplies	935
Purchased Services (e.g., sampling and analysis)	
a. Electricity	28,774
b. Equipment Rental	2,047
Administration	0
Insurance, Taxes, and Licenses	0
Maintenance Reserve and Contingency Costs	40,000
Total Annual O&M Costs	104,742[a]

[a] Actual operating costs taken from City of Eau Claire, Air Stripper Grant Report, for the first full calendar year of operation, 1988. A $40,000 annual repair/replacement maintenance grant is given to the City Eau Claire. Reportedly, there has not yet been need for use of these funds.

REFERENCES

1. Bidding Schedule, Eau Claire Municipal Well Field Air Stripping System, Eau Claire, Wisconsin, undated.

2. CH2M Hill, Operations and Maintenance Mannual, Air Stripping Facility, Eau Claire Municipal Well Field, Eau Claire, Wisconsin, October 1987.

3. City of Eau Claire, Wisconsin, Air Stripper Grant Report, January 1989.

4. Eau Claire Municipal Well Field Air Stripper Tower Data Sheets, August 31, 1987, to February 15, 1989.

5. U.S. EPA-Region 5, Decision Summary, Eau Claire Municipal Well Field Site, March 31, 1988.

6. U.S. EPA-Region 5, Record of Decision, Initial Remedial Alternative Selection, Eau Claire Municipal Well Field Site, June 10, 1985.

APPENDIX D

EGLIN AIR FORCE BASE

Case Study of Ground Water Biodegradation Treatment System

DISCLAIMER

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CASE STUDY OF THE EGLIN AIR FORCE BASE GROUND WATER BIODEGRADATION SYSTEM

Introduction

A full-scale ground water withdrawal and reapplication system was operated at Eglin Air Force Base (AFB) near Fort Walton Beach, Florida for 18 months during a system test program. Contamination at this site resulted from an underground pipeline leak of jet fuel (JP-4) discovered in April 1984. Approximately 5,000 yd^3 of soil and aquifer material was contaminated by an estimated 20,000 gallons of spilled jet fuel. A portion of the fuel residuals have been removed through a combination of biodegradation, hydraulic washing, and above-ground aeration. Time for remediation of the site was projected at 10 years. Capital costs of the program have amounted to $95,000 with annual operation and maintenance expenses totaling $152,500.

Site Description and Background

Each year, the U.S. Air Force stores and transfers millions of gallons of JP-4 jet fuel at over 200 installations. As a result, fuel leaks and spills are, by far, the most frequent sources of soil and ground water contamination at these facilities. The Air Force Engineering and Services Center (AFESC), located at Tyndall AFB, Florida, is responsible for developing and testing improved methods of soil and ground water decontamination. In 1984, AFESC initiated a pilot-scale test of enhanced biodegradation at a site on Kelly AFB, Texas. Soil permeability problems experienced at Kelly AFB resulted in inadequate delivery of hydrogen peroxide and nutrients through injection wells and, as a result, a second site with more favorable soil permeability was selected at Eglin AFB, Florida.

In April 1984, a leak was discovered in an underground jet fuel pipeline in the Eglin AFB petroleum storage area. A preliminary site characterization estimated that 30,000-45,000 gallons of JP-4 had contaminated approximately 5,000 yd^3 of soil and shallow aquifer material. Follow-up sampling in August 1985 downgraded this estimate to 20,000 gallons of jet fuel.

The site is located in an area of unconsolidated and homogeneous coastal sands that extend down to 40 feet. Below the sand, a 400-foot confining layer of clay protects the deeper Floridian aquifer. The area of free product influence as it existed prior to initiation of biodegradation operations and the location of initial monitoring wells are illustrated in figure 1.

Process Description

One of the major objectives of the overall system test program was to ensure that a sufficient number of ground water and soil samples was taken to adequately assess biodegradation technology performance. On the basis of an initial soil vapor survey, 22 monitoring wells and 12 soil sampling locations were selected. These locations were subsequently increased to 40 monitoring wells and 16 soil sampling sites. Total organic carbon (TOC) was chosen as the general indicator of jet fuel contamination in the ground water and total petroleum hydrocarbons

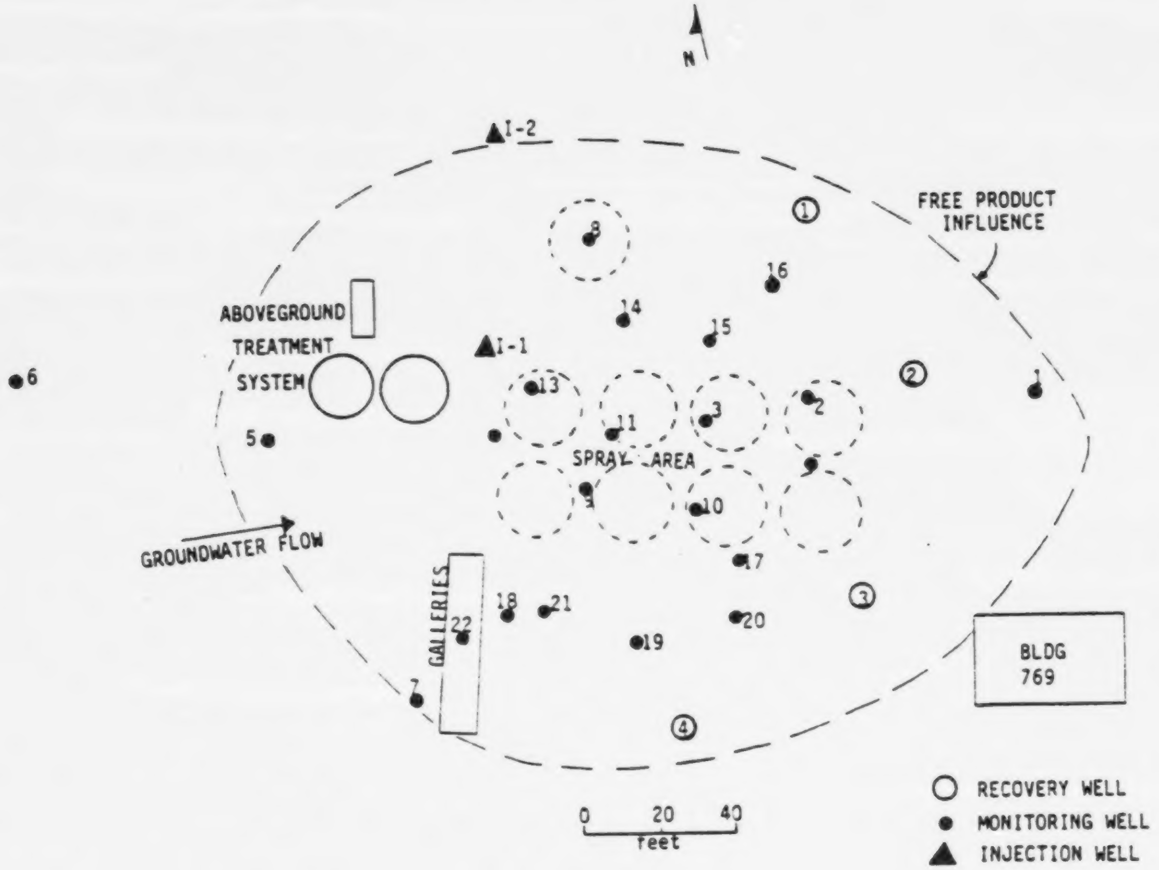

N
I-2
FREE PRODUCT INFLUENCE
①
8
16
ABOVEGROUND TREATMENT SYSTEM
14
15
I-1
6
13
②
1
11
3
2
5
SPRAY AREA
9
10
GROUNDWATER FLOW
17
GALLERIES
18
21
③
22
20
19
BLDG 769
7
④
RECOVERY WELL
MONITORING WELL
INJECTION WELL
0
20
40
feet

Figure 1. Eglin AFB Site Profile.

(TPH) was selected as the general indicator of soil contamination. Background levels established for these two parameters were 15 mg/L for TOC and 20 mg/kg for TPH.

Preliminary testing done on this project consisted of bench-scale degradation studies using contaminated soils and ground water from the site to determine the effects of nutrient and oxygen supplementation on the rate of contaminant biodegradation. Whereas most microcosm degradation studies monitor only aqueous phase contaminant biodegradation, this project attempted to quantify degradation of the total organic material within the reactors. Analysis of the aqueous phase showed that biodegradation was enhanced by the addition of a prepared nutrient mixture. Total extractable organics were degraded from 35 ppm to less than 0.2 ppm in 9 days. Analysis of the solid phase actually showed an increase in organics due to extraction and other analytical problems. Repeated attempts to measure biodegradation of JP4 in soil residuals failed to produce definitive results.

The ability of the shallow aquifer to produce sufficient water for recirculation of nutrients and oxygen was evaluated through a series of pump tests on all recovery and injection wells. Design characteristics of these wells are shown in figure 2.

A primary objective of system design was the delivery of an adequate supply of oxygen for mineralization of fuel hydrocarbons. The O_2 requirement on the basis of stoichiometric reactions was determined to be 3.1 pounds of O_2 per pound of benzene or 3.5 pounds of O_2 per pound of octane. Overall, it was determined that 40,000 pounds of O_2 would be required for complete mineralization of the estimated 16,000 lbs. of hydrocarbons present at the site.

The three basic technologies available for oxygen and nutrient injection are injection wells, infiltration galleries, and surface application. Since the ground water at the Eglin site is quite shallow, and no significant stratification exists in the unsaturated zone or the shallow saturated zone, surface application would be the technology of choice. Due to the research nature of this project, however, all three technologies were attempted at the site. The application systems were designed to receive approximately 10 gpm each or six to seven million gallons over the course of the study. The injection wells were previously shown in figure 2. The shallow, gravel-filled trenches used as infiltration galleries are depicted in figure 3. The surface application system provided an even distribution of nutrient and oxygen over an 1,800 square-foot area via a sprinkler system. A schematic diagram of the overall above-ground treatment and application system is given in figure 4.

Operational and Performance Data

The prepared nutrient mixture was added on a batch basis of 150 lbs/week and fed at a delivery concentration of 1,000 ppm. Nutrient solutions were added three times a week at durations of 4 hours each. These nutrient application rates were designed to be in excess of microbial requirements. Problems at the site have

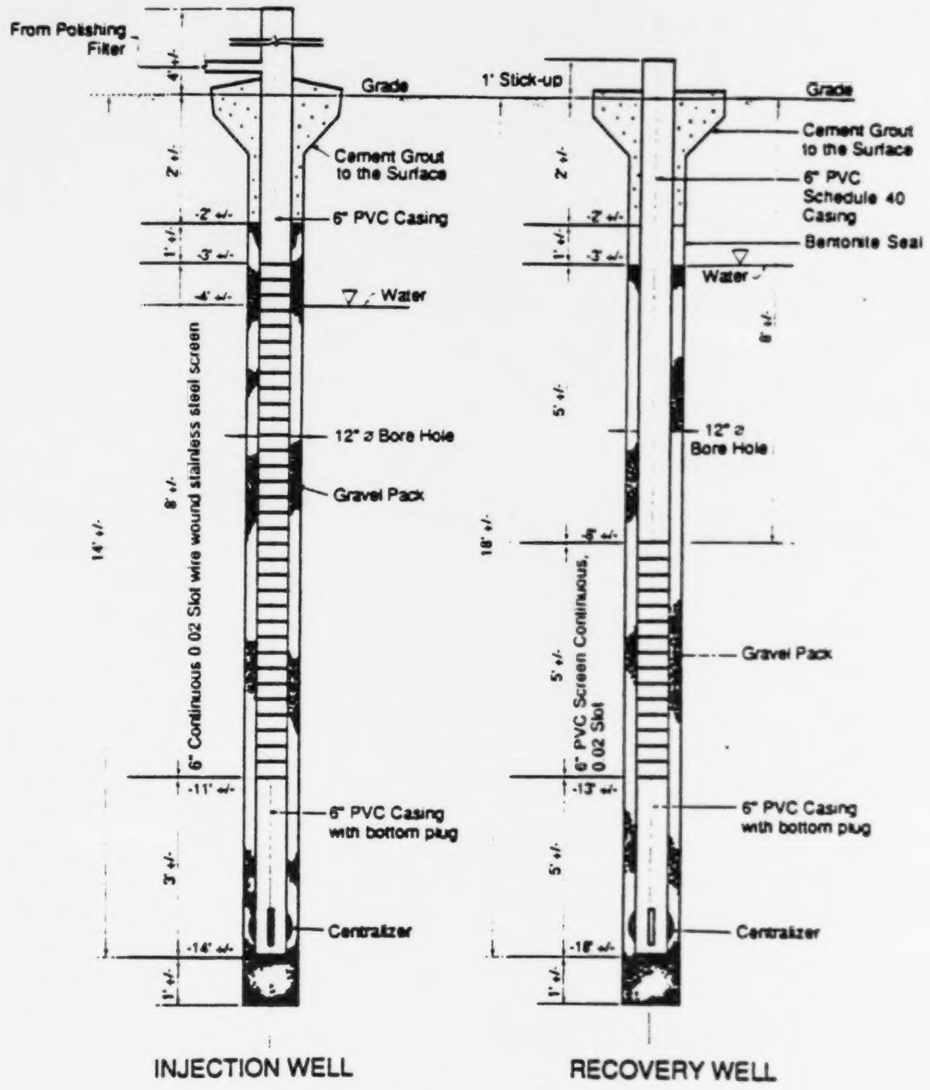
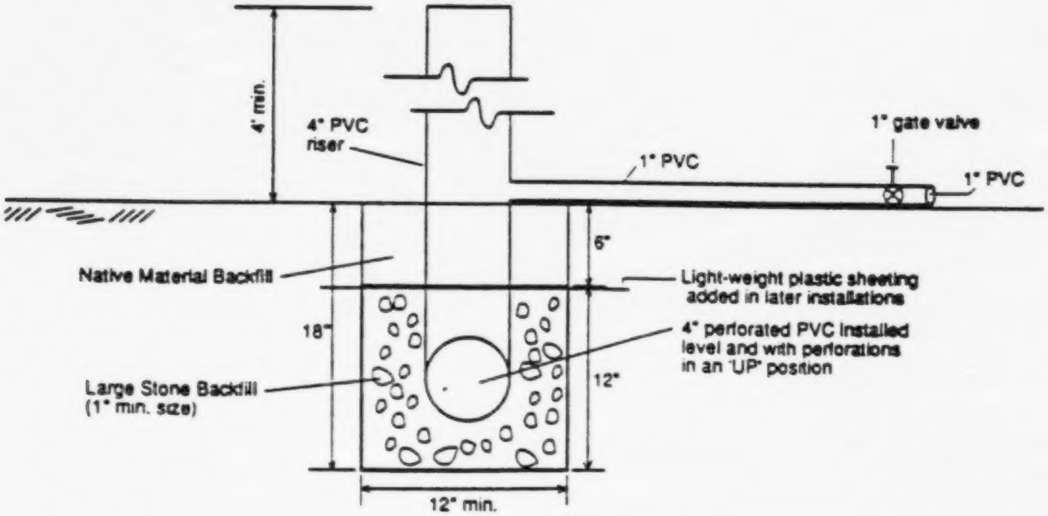

From Polishing Filter
4' +/-
Grade
2' +/-
Cement Grout to the Surface
-2' +/-
6" PVC Casing
1' +/-
-3' +/-
-4' +/-
Water
6" Continuous 0.02 Slot wire wound stainless steel screen
12" ⌀ Bore Hole
8' +/-
Gravel Pack
14' +/-
-11' +/-
6" PVC Casing with bottom plug
3' +/-
Centralizer
-14' +/-
1' +/-
INJECTION WELL
1' Stick-up
Grade
Cement Grout to the Surface
2' +/-
6" PVC Schedule 40 Casing
-2' +/-
Bentonite Seal
1' +/-
-3' +/-
Water
8' +/-
5' +/-
12" ⌀ Bore Hole
18' +/-
-8' +/-
5' +/-
6" PVC Screen Continuous, 0.02 Slot
Gravel Pack
-13' +/-
6" PVC Casing with bottom plug
5' +/-
Centralizer
-18' +/-
1' +/-
RECOVERY WELL

Figure 2. Recovery and Injection Well Design.



4' min.
4" PVC riser
1" PVC
1" gate valve
1" PVC
6"
Native Material Backfill
Light-weight plastic sheeting added in later installations
18"
4" perforated PVC installed level and with perforations in an 'UP' position
Large Stone Backfill (1" min. size)
12"
12" min.

Figure 3. Infiltration Gallery Design.

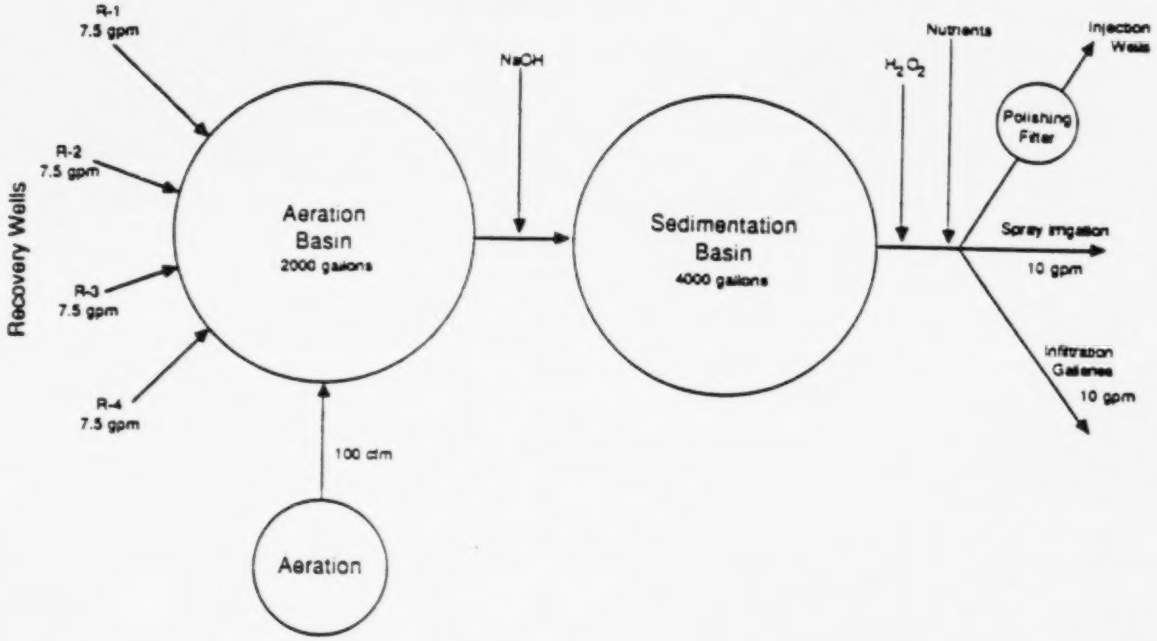

R-1
7.5 gpm
R-2
7.5 gpm
R-3
7.5 gpm
R-4
7.5 gpm
Recovery Wells
Aeration Basin
2000 gallons
100 cfm
Aeration
NaOH
Sedimentation Basin
4000 gallons
H_2O_2
Nutrients
Polishing Filter
Injection Wells
Spray Irrigation
10 gpm
Infiltration Galleries
10 gpm

Figure 4. System Flow Diagram.

been experienced with regard to in-situ peroxide stability as determined by tests conducted in the infiltration galleries. The observance of gas bubbles above the infiltration galleries and the failure to observe peroxide in any downgradient wells led to the conclusion that peroxide decomposition was very rapid and resulted in wasteful off-gassing of oxygen. Several experiments have been conducted to determine the cause of hydrogen peroxide decomposition. Both biological and inorganic reactions have been identified as being responsible for this instability. A series of laboratory and field experiments have lead to the conclusion that catalase enzymes released by aerobic bacteria near the points of injection are the major cause of rapid peroxide decomposition and oxygen off-gassing.

During the initial weeks of operation, the four recovery wells produced over 40 gpm of continuous flow; over the past 15 months, well production has decreased to 32 gpm. The total volume of water passing through each of the primary application systems to date is:

Spray Irrigation	7.8 million gallons
Infiltration Galleries	6.5 million gallons
Injection Wells	1.0 million gallons
Total	15.3 million gallons

Problems have been experienced with clogging and reduced flow in the injection wells and the infiltration galleries. The spray irrigation area has performed well and has continuously received at least 10 gpm over the 1,800 ft^2 area. A total of 190 pore volumes of nutrient and oxygen-enriched water passed through the contaminated soils in the spray area.

Performance data available to date shows decreased levels of BTX (total benzene, toluene, and xylenes) as determined from sampling locations within the spray application area and downgradient of the infiltration galleries. On the other hand, fuel residuals in soils above the water table in areas influenced by injection wells, infiltration galleries, and spray areas have shown no solid evidence of enhanced biodegradation, nor was significant hydraulic washing observed.

As a result of modifications to the aeration basins, a significant quantity of fuel residuals have been removed at this location. It is estimated that the aeration basin has effected removal of at least 2,000 pounds of hydrocarbons from the 16,000,000 gallons of water pumped through the site.

Based on current experiences regarding oxygen delivery rates, and assuming the continued volatilization of 2,000 pounds of hydrocarbons per year, it is estimated that at least 4 more years will be required to deliver minimum stoichiometric oxygen requirements and thus complete site remediation. Switching the entire site to the spray system would be one practical alternative for speeding up site cleanup.

been experienced with regard to in-situ peroxide stability as determined by tests conducted in the infiltration galleries. The observance of gas bubbles above the infiltration galleries and the failure to observe peroxide in any downgradient wells led to the conclusion that peroxide decomposition was very rapid and resulted in wasteful off-gassing of oxygen. Several experiments have been conducted to determine the cause of hydrogen peroxide decomposition. Both biological and inorganic reactions have been identified as being responsible for this instability. A series of laboratory and field experiments have lead to the conclusion that catalase enzymes released by aerobic bacteria near the points of injection are the major cause of rapid peroxide decomposition and oxygen off-gassing.

During the initial weeks of operation, the four recovery wells produced over 40 gpm of continuous flow; over the past 15 months, well production has decreased to 32 gpm. The total volume of water passing through each of the primary application systems to date is:

Spray Irrigation	7.8 million gallons
Infiltration Galleries	6.5 million gallons
Injection Wells	1.0 million gallons
Total	15.3 million gallons

Problems have been experienced with clogging and reduced flow in the injection wells and the infiltration galleries. The spray irrigation area has performed well and has continuously received at least 10 gpm over the 1,800 ft^2 area. A total of 190 pore volumes of nutrient and oxygen-enriched water passed through the contaminated soils in the spray area.

Performance data available to date shows decreased levels of BTX (total benzene, toluene, and xylenes) as determined from sampling locations within the spray application area and downgradient of the infiltration galleries. On the other hand, fuel residuals in soils above the water table in areas influenced by injection wells, infiltration galleries, and spray areas have shown no solid evidence of enhanced biodegradation, nor was significant hydraulic washing observed.

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Based on current experiences regarding oxygen delivery rates, and assuming the continued volatilization of 2,000 pounds of hydrocarbons per year, it is estimated that at least 4 more years will be required to deliver minimum stoichiometric oxygen requirements and thus complete site remediation. Switching the entire site to the spray system would be one practical alternative for speeding up site cleanup.

Cost Data

Limited cost data are available for this project; table 1 provides a summary of available capital and O&M costs. At the time of receipt of this data package from Tyndall AFB (March 30, 1989), the projected cleanup time was 10 years at a total cost of $1.7 million for remediation of 5,000 yd^3 of soil and aquifer materials. This would indicate a unit cost of approximately $340 per yd^3 of contaminated material. The accuracy of this estimated unit cost is uncertain because of concerns noted in the case disclaimer and in the text of the main report regarding data quality and completeness.

TABLE 1. AVAILABLE COST DATA FOR SITE REMEDIATION AT EGLIN AFB

Cost component	Cost, $
CAPITAL COSTS, $	
Installation of recovery and pumping wells	50,000
Injection system	40,000
Iron removal	5,000
TOTAL	$ 95,000
ANNUAL O&M COSTS, $/yr	
Chemical package (chemicals and equipment)	45,000
Labor, supervision, and engineering	60,000
Power	2,500
Maintenance	20,000
Sampling and analysis	25,000
TOTAL	$152,500/yr

Source: Data package supplied by Mr. Douglas Downey, USAF, Tyndall AFB, FL (3/30/89).

REFERENCES

1. Data package supplied by Douglas Downey, USAF, Tyndall AFB, FL (3/30/89).

2. Telephone Conversation between Alliance and Doug Downey, USAF, Tyndall AFB. June, 1989.

APPENDIX E

McCLELLAN AIR FORCE BASE

*Case Study of Ground Water Extraction
and Treatment System*

DISCLAIMER

This case study was prepared based on data provided to Alliance Technologies Corporation by various sources. Alliance recognizes that significant data gaps and inconsistencies may exist in the case study because the degree of data quality and completeness could not be defined.

CASE STUDY OF THE McCLELLAN AIR FORCE BASE GROUND WATER TREATMENT SYSTEM

Introduction

The McClellan Air Force Base (AFB) ground water treatment system began operations in March 1987 for the remediation of contaminated ground water. The overall remedial design consists of a ground water extraction system, a flexible membrane cover (cap) over an estimated 1.3 to 2.6 million yd^3 of contaminated material, and a ground water treatment system consisting of air stripping, incineration, biological wastewater treatment, and carbon filtration. As of the current date, site remediation is still in progress and a forecasted time of completion is unknown. Actual remediation capital costs totaled $11,700,000. Average annual operation and maintenance costs are $1,641,000, based on 2 years of operation.

Site Description and Background

The McClellan AFB site is located approximately 7 miles northwest of Sacramento, California and northwest of the junction of the Sacramento and American rivers. The site area is shown in figure 1. Nine (9) separate waste disposal sites were identified in Phase I of the Source Control Feasibility Study and are included in Area D as shown in figure 1. Area D is located in the northwestern portion of McClellan AFB and covers about 10 acres. The nine disposal sites are categorized by their former use as follows:

- Sludge disposal, oil burning or refuse burning and burial pits--Site Nos. 1, 2, 3, 4, 5, and 26.
- Skimmed oil burning pit--Site No. 6
- Sodium valve trench--Site No. 27
- Industrial sludge landfarm--Site No. 33

During subsequent investigations, three (3) additional sites were identified: A, S, and T. The area covered by Sites 1, 2, 3, 4, 5, 6, 26, 27, A, S, and T is about 20 acres. The area covered by the general location of Site 33 is about 5 acres.

McClellan AFB was established in 1936 as a new air repair depot and supply base for the War Department. It currently operates as an Air Force Logistics Command Base, responsible for repair and modification of assigned aircraft.

Various McClellan operations generated hazardous waste in the past. Throughout the 50 years that the base has been operational, numerous types of hazardous material have been used, including degreasing solvents, paint strippers, and plating chemicals. Past disposal practices included landfills, burial pits, open burning, incineration, sludge drying beds, and landfarms.

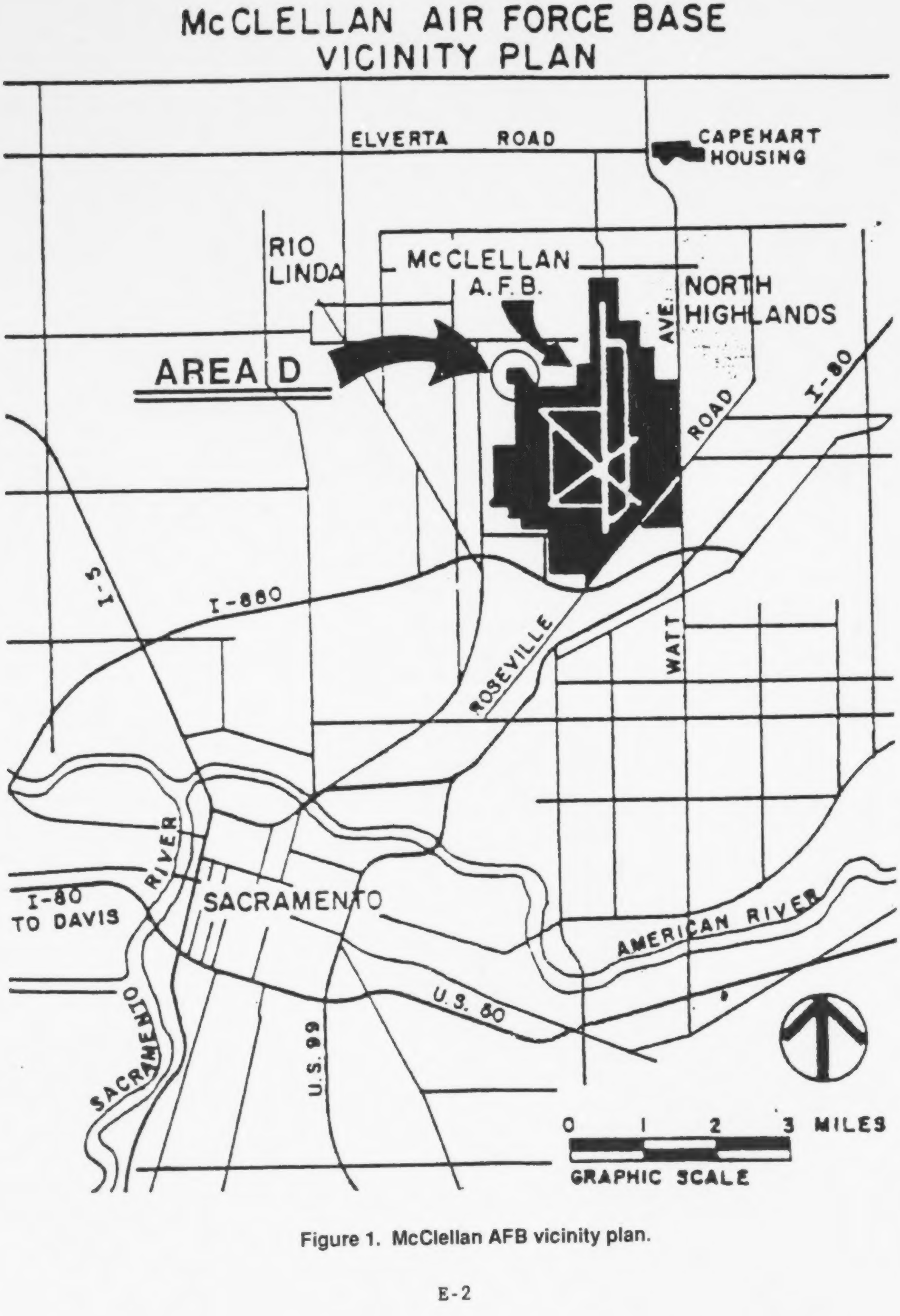
McCLELLAN AIR FORCE BASE
VICINITY PLAN
ELVERTA ROAD
CAPEHART HOUSING
RIO LINDA
McCLELLAN A.F.B.
NORTH HIGHLANDS
AREA D
AVE.
ROAD
I-80
I-5
I-880
ROSEVILLE
WATT
RIVER
SACRAMENTO
I-80 TO DAVIS
AMERICAN RIVER
U.S. 80
U.S. 99
SACRAMENTO
0 1 2 3 MILES
GRAPHIC SCALE

Figure 1. McClellan AFB vicinity plan.

A brief summary of the disposal practices including the periods that the sites were in use, follows.

- Site No. 1 was used as a refuse-burning and burial pit from 1959 to 1962.
- Site No. 2 was used as an industrial sludge disposal and oil-burning pit, and as a refuse-burning and burial pit. Waste solvents were also periodically burned at this site. The site was operated from 1962 to 1979.
- Site No. 3 was used as an industrial sludge disposal and oil-burning pit from 1962 to 1965.
- Site No. 4 was used as an industrial sludge disposal and oil-burning pit from 1976 to January 1981. The sludge and surrounding contaminated soil at Site No. 4 has been excavated and disposed of at a licensed Class I landfill. The excavated area has been backfilled and graded.
- Site No. 5 was used as an industrial sludge disposal and oil-burning pit from 1972 to 1978. Waste solvents were also periodically burned at this site.
- Site No. 6 was used to burn skimmed oil from the main sludge disposal pits from 1972 to 1978.
- Site No. 26 was used as an industrial sludge disposal and oil-burning pit in the early 1960's. The site was covered during the construction of Building No. 1093.
- Site No. 27 was used to burn sodium valves from aircraft engines from the late 1940's to the early 1950's.
- Site No. 33 was used for temporary landfarming of industrial waste treatment sludge in 1972.
- Site S was probably used for fuel, solvent, sludge, and debris disposal and also for burning. The site was opened sometime between 1962 and 1964 and closed sometime between 1965 and 1968.
- Site T was probably used for fuel, solvent, and industrial sludge disposal from 1964 to 1966.
- Site A is a trench or narrow pit that runs between Sites S and T.

Before 1977, fire training may have been performed in conjunction with Site Nos. 2, 3, 4, 5, and 26. Contaminated JP-4 (jet fuel) was used in the fire training proficiency exercises.

In general, the types of waste encountered at the site include metal, wood, concrete, glass, bricks, burning debris, roofing shingles, and mixtures of sludge and soil. Varying levels of volatile organics, base/neutral compounds, trace metals and cyanide have been found in the disposal pits and the surrounding soil. Based upon aerial photographs and the results of a shallow (40 - 100 ft.) exploration program, there are about 38,300 yd^3 of waste material as detailed in table 1. The estimated volume of 60,000 yd^3 of sludge and surrounding contaminated soil comprises roughly 2 to 4 percent of the total estimated volume of contaminated material. The total volume of contaminated soil ranges from 1.3 to 2.6 million yd^3.

Additional site characterization data has been developed for waste, soil, and ground water samples. Tables 2, 3, and 4 summarize available concentrations for these three matrices.

TABLE 1. WASTE VOLUME

Site No.	Waste depth (ft)	Waste volume (yd^3)
1	11-16	5,300
2	3-5.5	3,300
3	.5-17	22,700
5	4-9	4,200
S	4	1,400
T	4-5	1,400
Total		38,300

TABLE 2. POLLUTANT CONCENTRATIONS IN WASTE SAMPLES

Pollutant	Avg. conc. (ppb)	Max. conc. (ppb)
Volatile Organics--		
1,1,1-Trichloroethane	70,536	300,000
Toluene	59,208	330,000
Trichloroethylene	48,708	350,000
Acetone	32,300	65,000
Total Xylenes	29,612	140,000
1,1-Dichloroethane	20,828	110,000
Base/Neutrals--		
1,2-Dichlorobenzene	97,062	380,000
1,4-Dichlorobenzene	61,858	520,000
bis(2-ethylhexyl)phthalate	57,948	250,000
4-methylphenol	41,750	76,000
Metals--		
Chromium	170	180
Nickel	41	55
Cyanide--	18	100

TABLE 3. POLLUTANT CONCENTRATIONS IN SOIL SAMPLES

Pollutant	Avg. conc. (ppb)	Max conc. (ppb)
Volatile Organics--		
Acetone	32,243	76,000
2-Butanone	13,000	13,000
Toluene	5,180	10,000
Total Xylenes	4,457	11,000
Base/Neutrals--		
Naphthalene	3,500	3,500
bis(2-ethylhexyl)phthalate	1,750	2,200
Cyanide--	1.5	1.5

TABLE 4. POLLUTANT CONCENTRATIONS IN GROUND WATER SAMPLES

Pollutant	Well avg. (ppb)	Site avg. (ppb)	Max conc. (ppb)
Volatile Organics--			
1,1-Dichloroethylene	11,687	11,687	63,000
1,1,1-Trichloroethane	3,559	3,235	12,000
Trichloroethylene	2,966	2,966	11,000
Methylene chloride	3,175	1,155	5,000
Acids--			
Phenol	400	36	400
Base/Neutrals--			
1,2-Dichlorobenzene	45	20.5	100
Metals--			
Chromium (total)	93.3	25.5	120
Nickel	67.5	24.5	100
Zinc	43.8	19.9	73
Lead	50.5	18.4	93
Pesticides--			
Aldrin	4.4	0.8	7.0

Process Description

Following a thorough investigation of all potential remedial measures for this site, the recommended cost-effective alternative was capping of the site and installation of a ground water extraction and disposal system. The extraction system was designed as a containment system due to the unknown location of the contaminant plume. The extraction system is currently remediating the saturated zone. Future plans call for extension of the system to the unsaturated zone. A typical cross section of the waste pits in Area D and the components of the recommended remedial action measures are shown in figure 2. A schematic diagram of the ground water treatment plant is provided in figure 3. The cap is composed of layers of clay, compressed soil, a plastic liner, and natural vegetation. Its purpose is to prevent percolation of rain water and restrict future contamination of the unsaturated zone beneath the pits. The extraction system is composed of six wells screened to a depth of 160 ft and drawing approximately 200 gpm. Since that time, the flow has been reduced to 80 gpm which has proved adequate to maintain drawdown in the area. The ground water treatment plant consists of a high temperature (120°F) air stripper, an incinerator for destruction of VOC-laden offgases from the air stripper (operating at 1800°F), a carbon adsorption system, and a biological wastewater treatment system. The ground water is heated in two heat exchangers prior to entering the stripper and stripper offgases are also heated by incinerator offgases prior to entering the incinerator. Ground water leaving the air stripper is pumped through a granular activated charcoal filter system for removal of nonvolatile organic compounds and trace metals. There are six carbon filters to optimize carbon regeneration. The biological treatment plant has two units in parallel containing a special bio-film for destruction of water-soluble organics such as acetone and methyl ethyl ketone. In August 1988, another extraction well system, composed of 4 wells in Area C, was brought online.

Operational and Performance Data

Details of the current active remedial operations at the McClellan site are summarized below.

Area D Extraction System (6 extraction wells)

Startup:	3/16/87
Initial flow:	170 gpm
Current flow:	80 gpm
Depth:	160 ft
Total volume treated as of 3/15/89:	95.9 million gallons

Treatment Plant

Design capacity	1000 gpm
Current flow	240 gpm

Air stripper--Operates at 120°F. Removes volatile organics (99 percent)

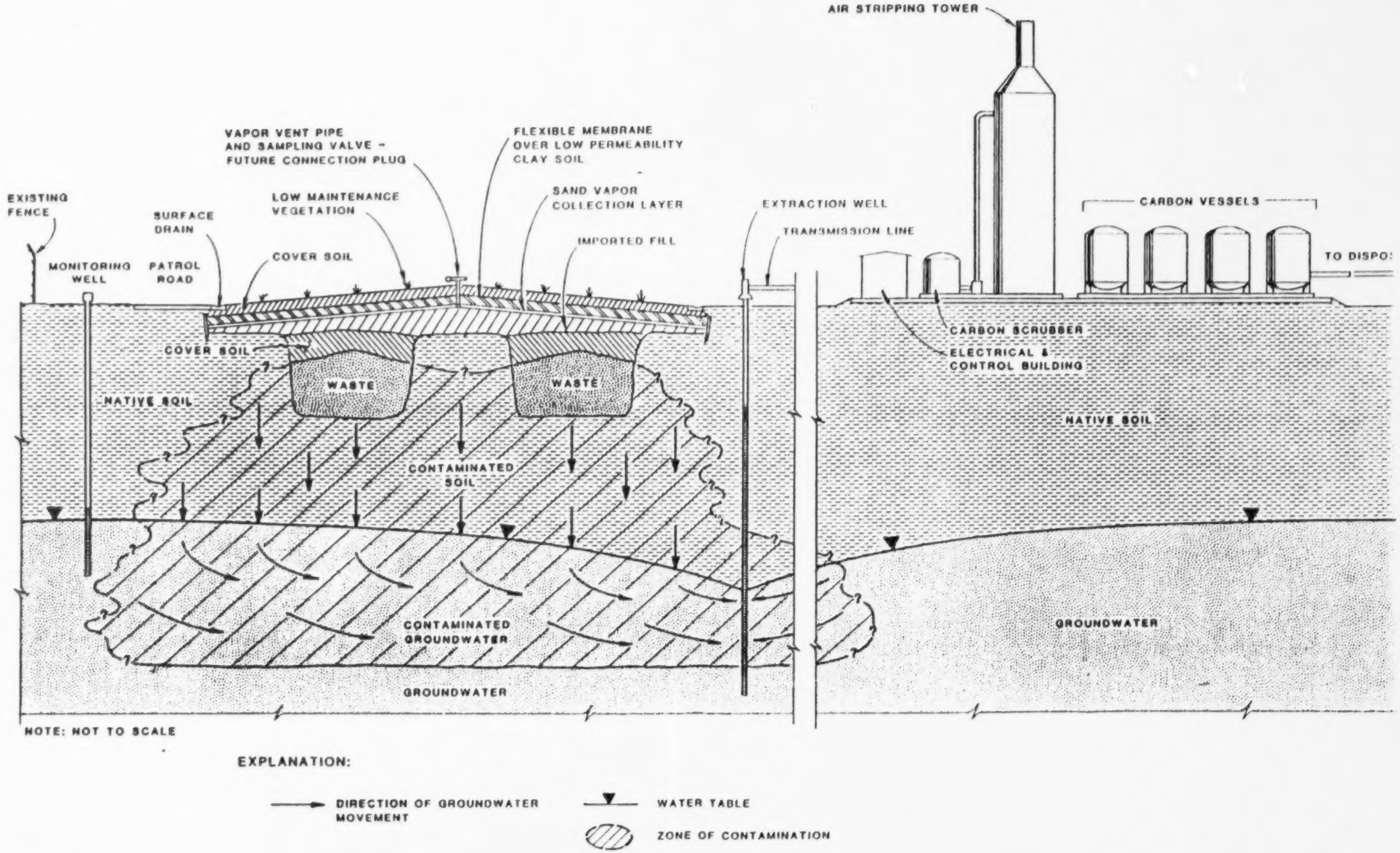
AIR STRIPPING TOWER
VAPOR VENT PIPE AND SAMPLING VALVE - FUTURE CONNECTION PLUG
FLEXIBLE MEMBRANE OVER LOW PERMEABILITY CLAY SOIL
EXISTING FENCE
LOW MAINTENANCE VEGETATION
SAND VAPOR COLLECTION LAYER
EXTRACTION WELL
CARBON VESSELS
SURFACE DRAIN
IMPORTED FILL
TRANSMISSION LINE
MONITORING WELL
PATROL ROAD
COVER SOIL
TO DISPO:
CARBON SCRUBBER
ELECTRICAL & CONTROL BUILDING
COVER SOIL
WASTE
WASTE
NATIVE SOIL
NATIVE SOIL
CONTAMINATED SOIL
CONTAMINATED GROUNDWATER
GROUNDWATER
GROUNDWATER
NOTE: NOT TO SCALE
EXPLANATION:
DIRECTION OF GROUNDWATER MOVEMENT
WATER TABLE
ZONE OF CONTAMINATION

Figure 2. Source control for Area D, McClellan AFB.

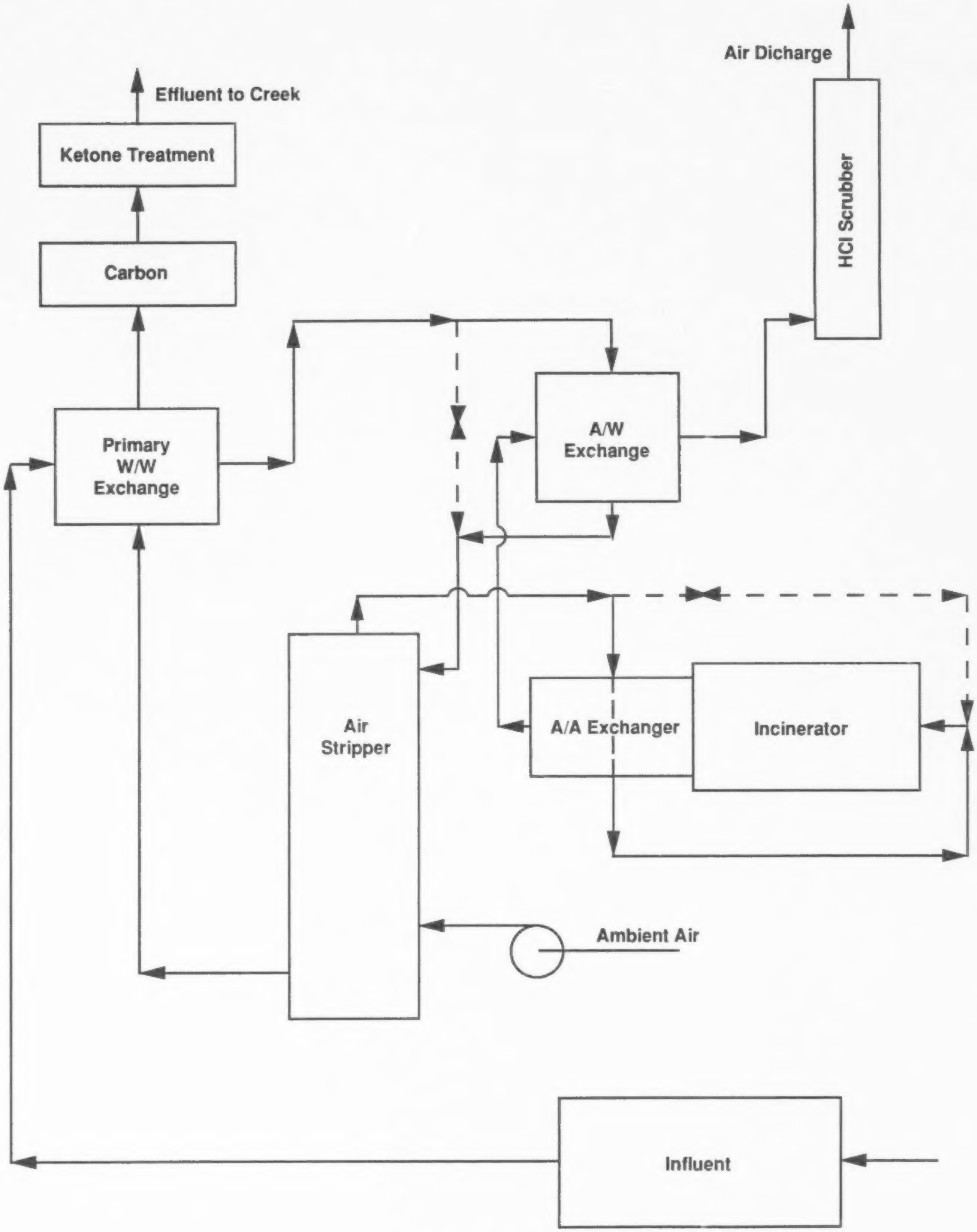
Air Dicharge
Effluent to Creek
Ketone Treatment
HCl Scrubber
Carbon
A/W Exchange
Primary W/W Exchange
Air Stripper
A/A Exchanger
Incinerator
Ambient Air
Influent

Figure 3. Groundwater treatment plant process flow diagram.

M3/67/G

Primary W/W heat exchangers--Influent water preheated
by water leaving stripper
Incinerator--Operates at 1800°F. Destroys volatile
organics in stripper off gas stream. Natural gas fired.
Caustic scrubber--Neutralizes HCl formed by destruction
of chlorinated hydrocarbons.
A/A heat exchanger--Stripper off gas preheated by air
leaving incinerator.
A/W heat exchanger--Water stream heated by recovery of
heat from incinerator stream.
Carbon filters--six beds, 20,000 lb of GAC each, three
trains of two (lead and polish). Removes nonvolatile organics
and any trace volatiles not removed by stripper. Regenerated
offsite.
Biological treatment--Fixed film, aerobic, decay mode
reactors. Removes ketones.

Design Criteria

Treat up to 1000 gpm
Effluent quality water--Nondetectable volatile organics
--Ketones <1 ppm
--Requirements of NPDES permit
Air--Zero discharge of volatiles. Requirements of
permit by Sac APCD.
No disposal of hazardous residuals/sludges.
95 percent uptime.

Available performance data for this site are provided in tables 5 and 6. Table 5 depicts plant influent levels for four key compounds since startup in March 1987. Several high peaks were observed during the first year and, in general, concentrations have stabilized at lower values since then. Table 6 provides a summary of performance data for January 1989 for a number of key parameters. The data indicate that all compounds are being effectively destroyed such that all effluent concentrations are below detection limits.

An ambient air monitoring program over Area D is being conducted and no releases to the atmosphere have been noted. Adequate drawdown is being maintained in the water table as verified by frequent static water level soundings. The contaminant plume does not appear to be spreading outward.

A test burn has been conducted on the air discharge from the ground water treatment plant incinerator and results indicate that the incinerator destroys 99 percent of the organics stripped from the ground water. The plant operates under an NPDES permit and discharges 240 gpm to a nearby creek. Organic compounds are removed to nondetectable levels.

Cost Data

Cost estimates prepared at the conceptual design phase of this project (1984) are shown in tables 7 and 8. Table 7 presents a summary of capital and operating costs that were believed accurate to +40 percent and -20 percent. Total capital

TABLE 5. GROUND WATER TREATMENT PLANT INFLUENT LEVELS

Pollutant	Well concentration ranges, ppb March 1987 thru March 1988	 April 1988 thru August 1988
Acetone	5,000-100,000	1,000-5,000
1,1-Dichloroethylene	1,000-28,000	1,000-5,000
Trichloroethylene	200-3,900	100-900
1,1,1-Trichloroethane	50-2,100	50-300

TABLE 6. JANUARY 1989 PERFORMANCE DATA SUMMARY

Pollutant	Treatment plant concentrations Influent	 Effluent	Detection limit
EPA Method 601 (ppb)--			
1,1-Dichloroethylene	930-1680	ND	0.22
Vinyl chloride	170-1550	ND	0.30
Trichloroethylene	180-540	ND	0.20
1,1-Dichloroethane	82-165	ND	0.12
1,1,1-Trichloroethane	84-100	ND	0.29
EPA Method 602 (ppb)--			
Acetone	790-2800	ND	185
Methyl Isobutyl Ketone	190-410	ND	115
Methyl Ethyl Ketone	240-290	ND	225
Metals (ppm)--			
Chromium	0.007-0.012	ND	0.003
Cyanide (ppm)--	<0.5	<0.5	--

TABLE 7. ESTIMATED REMEDIATION COSTS

Description	Capital cost	Present worth O&M&R	Total Present worth
Flexible membrane cover	$1,280,000	$ 26,200	$1,306,200
Ground water extraction system	305,000	320,500	625,500
Ground water/vapor treatment system	1,071,000	1,894,800	2,965,800
Construction costs	$2,656,000	$2,241,500	$4,897,500
Mobilization (10%)	$ 265,000	-	$ 265,000
Engineering, legal and administration (16%)	439,000	-	439,000
Health and safety requirements (5%)	127,000	-	127,000
Subtotal	$3,487,000	$2,241,500	$5,728,500
Contingencies (30%)	1,046,000	672,500	1,718,500
Total	$4,533,000	$2,914,000	$7,447,000

Note: Costs are in 1984 dollars. Present worth is calculated based on an interest rate of 10 percent and a return period of 30 years. O&M&R refers to operation, maintenance, and replacement/repair.

Source: Data Package provided by J. Thomas Lawell, McClellan AFB (3/24/89).

costs amounted to $4,533,000, with annual operation and maintenance costs estimated at $232,400. The total estimated present worth of the project was $7,447,000, assuming a 30 year life. Projected annual operating and maintenance costs for the proposed remedial action are given in table 8.

Actual remediation costs provided in March 1989 are presented in table 9. Capital expenses equaled $11.7 million. Annual costs are based on 2 years of actual operation and amounted to $1,641,000 per year. Experience at this facility has shown that operating costs tend to be higher at startup when new technologies are applied to a unique site, when system debugging is ongoing, and when system components are being custom fit. Also, monitoring costs tend to be higher in the beginning to ensure that all regulatory concerns are being addressed.

Assuming a ten year project life at ten percent interest, the unit cost of ground water treatment is estimated to be about 4.5¢/gallon. The accuracy of this estimated unit cost is uncertain because of concerns noted in the case disclaimer and in the text of the main report regarding data quality and completeness.

TABLE 8. ESTIMATED ANNUAL OPERATING AND MAINTENANCE COSTS

Item	Annual O&M	Present worth O&M&R
Flexible Membrane Cover		
Crack Sealing	$ 1,000	$ 9,400
Slurry Seal or Overlay Replacement ($70,000 at year 15)	-	16,800
Subtotal	$ 1,000	$ 26,200
Extraction Well Field		
Pump Repair (one/yr at $1,500)	$ 1,500	$ 14,141
Monitoring Program		
Daily Flow (0.5 hr/day)	7,300	68,822
Weekly Water Levels (30 wells; 3 hr/wk)	6,200	58,451
Monthly Sampling (15 wells, 2 man-days/month)	7,700	72,593
Quarterly Sampling (15 wells, 4 man-days/year)	1,300	12,256
Reporting (4 times/yr at 5 man/days each)	6,400	60,337
Pump Replacement ($18,000 at year 10)	-	6,900
Pump Replacement ($18,000 at year 20)	-	27,000
Subtotal	$ 30,400	$ 320,500
Treatment System		
Power (at $0.075 per kWh)		
Well Pumps, 60 hp (353,000 kWh/yr)	$ 27,000	$ 254,546
Packed Tower Fan, 2 hp (12,000 kWh/yr)	1,000	9,428
Vapor Control Fan, 40 hp (235,000 kWh/yr)	18,000	169,697
Granulated Activated Carbon		
Vapor Control	80,000	754,211
Liquid Phase	50,000	471,382
Plant Maintenance	25,000	235,536
Subtotal	$201,000	$1,894,800
TOTAL	$232,400	$2,241,500

Note: Labor costs estimated at $40 per hour. Present worth of O&M&R cost is based on an interest rate of 10 percent and return period of 30 years. Costs of analytical services not included.

Source: Data Package supplied by J. Thomas Lawell, McClellan AFB (3/24/89).

TABLE 9. ACTUAL REMEDIATION COSTS

Item	Cost
REMOVALS	
Site 4 sampled and excavated	$ 2,500,000
CAPITAL EQUIPMENT	
a. Area D cap design and construction	$ 3,200,000
b. Area D extraction system design and construction.	$ 1,000,000
• Six extraction wells • Five additional monitor wells • Modeling, associated hardware	
c. Area C extraction system design and construction.	$ 1,200,000
d. Ground water treatment plant	$ 3,800,000
• Bought as a turnkey system • Includes 1 mile pipeline	
TOTAL CAPITAL COSTS:	$11,700,000
OPERATION AND MAINTENANCE	
a. Contract labor	$ 855,000/yr
• Staff 24 hr/day, 7 days/wk • 95 percent uptime • Includes wellfield monitoring • Reports • Small ticket repairs, hardware	

(continued)

TABLE 9 (continued)

Item	Cost
b. Reimbursable expenses (highly variable)	$ 90,000/yr
• Hardware, carbon, caustic, major repairs • Carbon regeneration cost nearly zero when air stripper is on line. • Miscellaneous work orders	
c. Natural gas (incinerator)	$ 55,000/yr
d. Electricity (pumps, wells, misc.)	$ 36,000/yr
e. Technical management	$ 47,000/yr
• Air Force Employees--contract management, performance evaluation	
MONITORING COST	
a. Lab cost, air and water analysis	$ 131,000/yr
b. Labor, Air Force technicians	$ 127,000/yr
c. Sampling and analysis of monitor wells	$ 300,000/yr
• Contractor performs quarterly	
TOTAL ANNUAL COSTS:	$1,641,000/yr

Source: Data Package supplied by J. Thomas Lawell, McClellan AFB (3/24/89).

REFERENCES

1. Data Package provided by J. Thomas Lawell, McClellan AFB (3/24/89).
2. Telephone Conversation between Alliance and Doug Mackensie, USAF, McClellan AFB. July, 1989.

APPENDIX F

PONDERS CORNER (LAKEWOOD) SITE

Case Study of Ground Water Extraction
with Air Stripping and Soil Vacuum Extraction

DISCLAIMER

This case study was prepared based on data provided to Alliance Technologies Corporation by various sources. Alliance recognizes that significant data gaps and inconsistencies may exist in the case study because the degree of data quality and completeness could not be defined.

CASE SUMMARY OF THE PONDERS CORNER (LAKEWOOD) SITE

Introduction

Remedial action at the Ponders Corner Site began in September, 1984 to remove volatile organic compounds from a contaminated aquifer. Contaminated ground water is extracted using two district water wells and pumped to a treatment system employing air strippers. A soil vapor extraction system went online during early 1988 to clean up the heaviest areas of contaminated soil. The ground water extraction and treatment system is expected to operate for a minimum of 10 years. Ground water is extracted from 2 wells and pumped to two air stripping towers, each operating at the design rate of 1000 gpm. System construction costs amounted to $640,000. Actual operating costs have averaged $22,000 per year but some expenses are accounted for by the municipal treatment plant.

Site Description and Background

The Ponders Corner Site (known as the Lakewood Site on the National Priorities List) is located south of the City of Tacoma, Washington next to Interstate 5 as shown in figure 1. The Lakewood Water District maintains two water production wells south of Interstate 5. Sampling of Lakewood wells H1 and H2 in 1981 by the U.S. EPA identified ground water contaminated primarily with tetrachloroethylene (PCE) and trichloroethylene (TCE). Subsequently, the wells were shut down in August, 1981.

An inspection by the Washington Department of Ecology (WDOE) in August, 1981 concluded that the primary source of soil and ground water contamination was the discharge of a dry cleaner's solvent-containing waste effluent to septic tanks and land surface. The dry cleaners is located about 800 feet northeast of the two contaminated Lakewood water wells. Approximately 15,000 to 20,000 gallons per day of effluent was deposited at the site. As a result of further monitoring and sampling, the highest level of ground water contamination was found in a monitoring well located approximately 50 feet from the cleaners. The maximum concentration of PCE detected was 3,880 ug/kg in the site area soil and 922 ug/L in the ground water. Maximum TCE concentrations detected were 5 ug/kg in the soil and 57 ug/L in the ground water.

In September, 1983, WDOE and the dry cleaner owners signed an agreement which called for the cleaners to cease disposing of dry cleaning wastes onsite, to remove contaminated soils, and to cooperate in the protection of the aquifer from contaminants released onsite. A September, 1984 EPA Initial Remedial Action was issued for the installation of a ground water treatment system consisting of two air stripping towers utilized to restrict the spread of contaminants in the aquifer and restore the water supply from wells H1 and H2. A Record of Decision was signed on September 30, 1985. The selected remedial alternative consisted primarily of continuing use of the air stripping treatment system for cleanup of the aquifer (utilizing production wells H1 and H2 for extraction of water with some system operation and equipment modifications), excavation of the septic tanks, and installation of a vacuum extraction system to remediate contaminated soil.

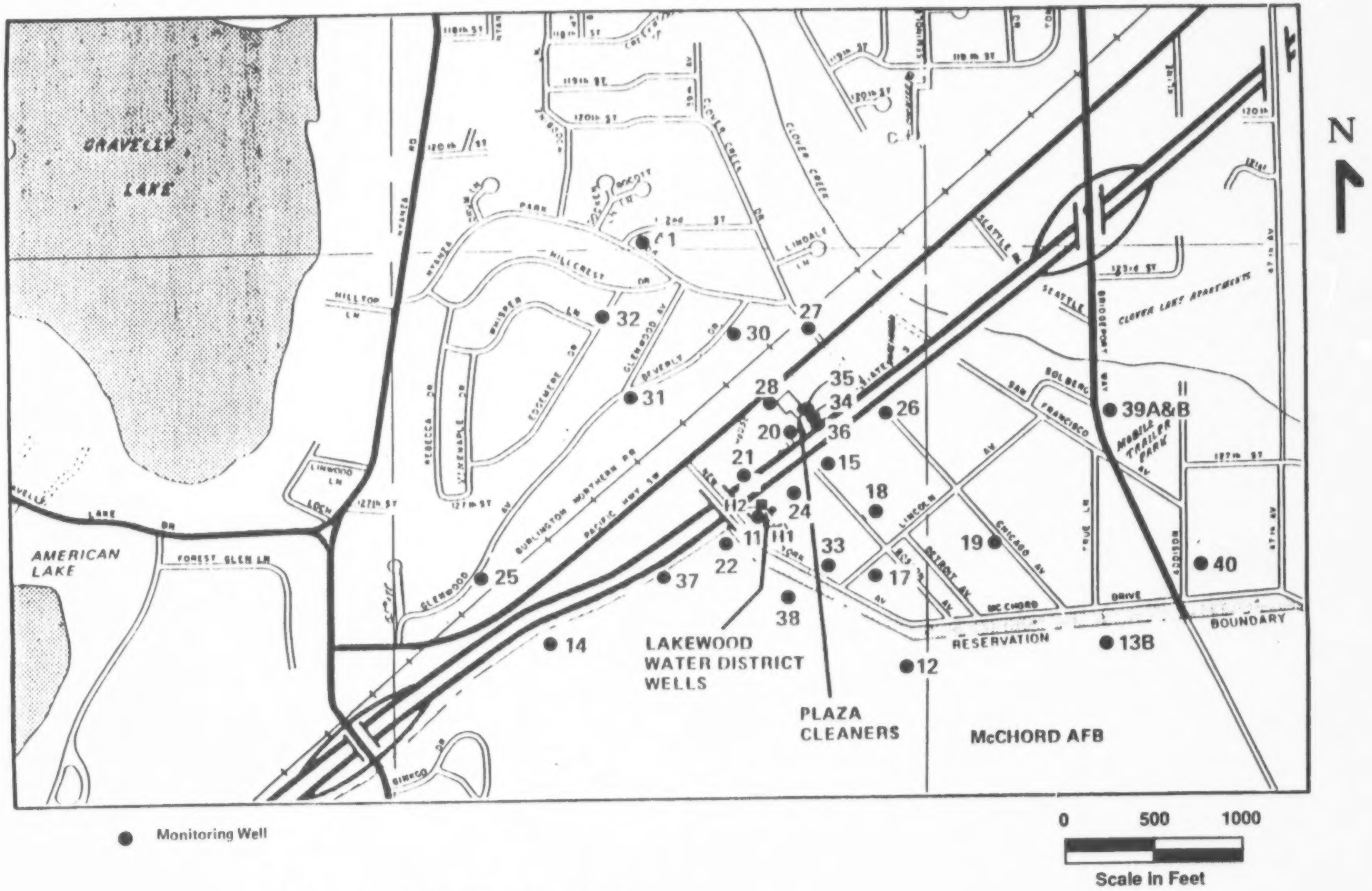
N
GRAVELLY LAKE
AMERICAN LAKE
LAKEWOOD WATER DISTRICT WELLS
PLAZA CLEANERS
McCHORD AFB
RESERVATION
BOUNDARY
CLOVER LAKE APARTMENTS
MOBILE TRAILER PARK
BRIDGEPORT WAY
SEATTLE
PACIFIC HWY SW
BURLINGTON NORTHERN RR
LINCOLN
CHICAGO AV
DETROIT AV
McCHORD
DRIVE
CLOVER CREEK
HILLCREST DR
FOREST GLEN LN
LAKE DR
127th ST
41
32
30
27
31
28
35
34
26
39A&B
20
36
21
15
18
112
24
11
111
33
19
22
17
40
25
37
38
14
13B
12
● Monitoring Well
0
500
1000
Scale In Feet

Figure 1. Ponders Corner Site Area.

(Reference: CH_2M Hill, Public Comment Feasibility Study, Ponders Corner, Washington, July 1985. US. EPA contract no. 68-01-6692)

Process Description

Contaminated ground water is extracted from two existing Lakewood production wells, H1 and H2. Both wells are approximately 110 feet deep. The ground water is then pumped to the ground water treatment system which consists of two packed towers. Water feed rates to each tower were designed at 1000 gallons per minute (gpm). The water is pumped to the top of the towers, atomized and cascades down through the packing material. Air is forced up through the tower and countercurrently contacts the contaminated ground water. The design air flow rate for each tower is 29,000 scfm. VOCs are stripped from the ground water by the air stream which exits at the top of the tower. Treated effluent is discharged to the Lakewood District water treatment system. At the design flow rate of 1000 gpm per tower and a nominal inlet concentration of 250 ppb PCE, each tower is designed to remove greater than 99.6 percent PCE.

The purpose of the soil vacuum extraction system is to remove volatile compounds from the areas of highest soil contamination and to reduce inhalation and dermal contact risks associated with uncontrolled excavation. The soil is characterized as silty, gravelly sand. Based on the construction permit application and a memo entitled "Lakewood SVES Operational Summary" (Draft, April 25, 1989), the vapor extraction system consists of ten vertical well pipes 18 feet deep, located in the area of highest expected contamination. The system also includes three perforated headers in the tops of the septic tanks. Above ground, the well heads are manifolded to a low volume, high pressure fan (600 cfm at 8" vacuum pressure at the wells and headers). The fan discharge passes through activated carbon filters and then to a pipe stack for discharge to the atmosphere. Sample taps are located at each well and at the main header to allow for periodic measurements to determine progress in removing VOCs. The gas manifold, valves, fan, motor, carbon filters, and electrical equipment are enclosed in a small building with exhaust ventilation for safety. Startup was planned for January, 1988 and was actually initiated on March 22, 1988.

Operational Data

The ground water extraction and treatment system began operation in September, 1984. The two Lakewood production wells, H1 and H2, typically operate at a combined average of 2000 gpm, supplying contaminated ground water to the air stripper treatment system. Monthly totals of ground water pumped from each well are shown in figure 2. Between November, 1986 and February, 1987, the well pumps were shut down to allow for maintenance of the air strippers. The ground water treatment system is expected to operate for a minimum of 10 years at current operating conditions.

The soil vapor extraction system (SVES) was designed based on the need to remove an estimated 5 lbs. of PERC from near surface soils. The design cleanup objective was to achieve well space PERC concentrations of less than 50 ppm. Design life was 6 months. The operational life has exceeded 6 months because the initial estimate of 5 lbs. of PERC was well below actual quantities encountered at the site.

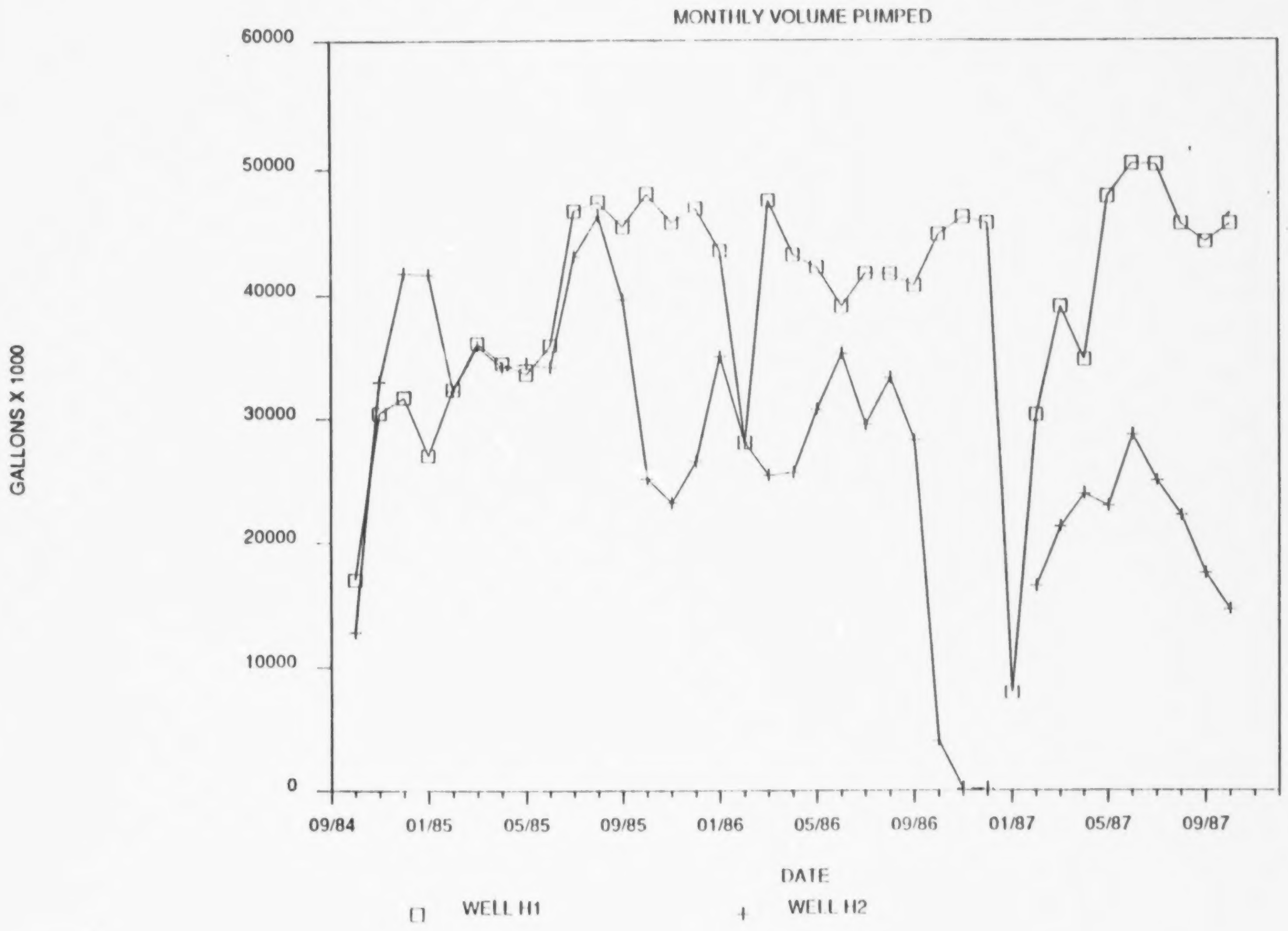

Figure 2. Monthly production of wells H1 and H2.

(Reference: CH_2M Hill, Final Aquifer Cleanup Assessment Report, Ponders Corner, Washington, February 1988. U.S. EPA contract no. 68-01-7251)

Performance Data

Average monthly PCE and TCE concentrations in influent ground water extracted from wells H1 and H2 are graphed in figures 3 and 4. Contaminant concentrations have generally been higher in well H2 because the well is closer to the contaminant source.

PCE levels in well H1 significantly decreased during the first three months of operation and between August, 1985 and September, 1987 remained below 10 ppb. From January, 1986 to September, 1987, PCE levels in well H2 varied between 90 and 30 ppb. Available data since September, 1985 indicate that PCE levels in the treatment system effluent have been below detection limits. The single highest measured treatment system effluent PCE concentration is below 0.7 ppb.

The highest measured well TCE concentration at startup was 33 ppb. From the end of November, 1985 to September, 1987, TCE was not detected in well H1. In the same timeframe, concentrations of TCE at well H2 have been below 1 ppb. Treatment system effluent TCE levels have generally been below detection limits. The highest single measured effluent TCE level was 5.7 ppb from tower 1.

Carbon adsorption capacity was consumed after one month of operation because of significantly higher than expected PERC contamination of near surface soil. The system was shut down for carbon replacement and a total of 330 lbs. of PERC had been collected, as opposed to the estimated 5 lbs. expected to be extracted from near surface soils. After startup, seven wells were isolated from the manifold to increase vacuum pressure and extraction rates at certain wells where PERC concentrations rebounded to higher levels during system shutdown.

The system was shut down a second time because carbon capacity was exhausted and spent carbon was replaced with regenerated carbon. After shutdown, significant PERC concentration excursions were measured in inactive wells. After startup, breakthrough was noted again. Although presumed attributable to moisture fouling of the carbon, it was determined that the system plumbing had been inadequately reconnected and PERC was bypassing the carbon bed.

Based on the "Lakewood SVES Operation Summary" (Draft, April 25, 1989) the system operated between January and April and progress was made in removing PERC. The decision was made to continue system operation beyond April, however, to attain the design objective of less than 50 ppm PERC in the wellspaces. Through April 3, 1989, 775 lbs. of PERC had been removed by the system.

Cost Data

Capital costs associated with the ground water treatment system and the soil vacuum extraction system are shown in table 1. The cost of the ground water system, including removal of septic tanks, modification of pumps and fans, and installation of 2 added monitoring wells, was initially estimated at $335,000 (EPA FS, July, 1985). Based on correspondence with the EPA RPM in June, 1989, the approximate actual construction cost for the air stripping system was $640,000.

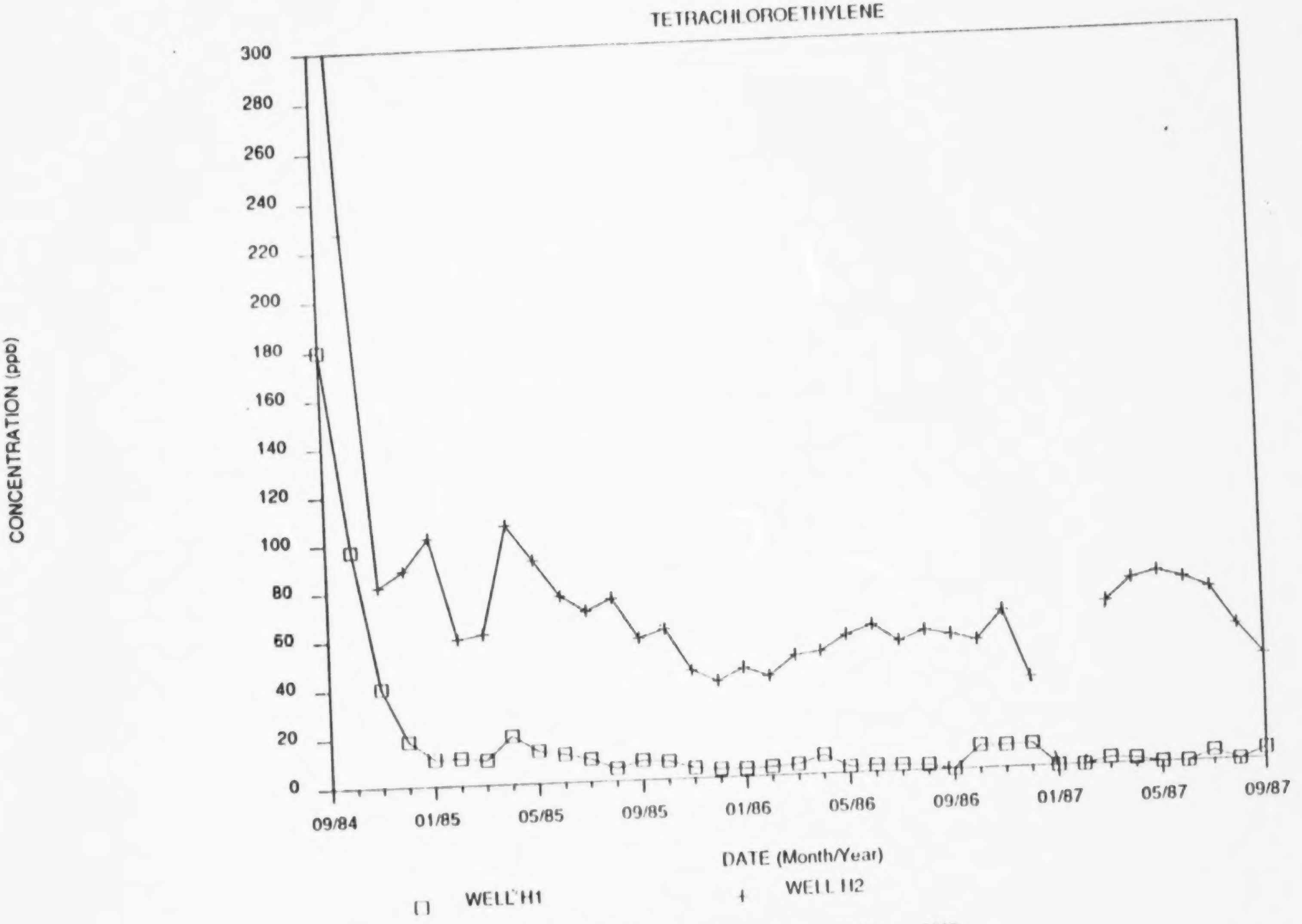

Figure 3. Tetrachloroethylene (PCE) concentrations of wells H1 and H2.

(Reference: CH_2M Hill, Final Aquifer Cleanup Assessment Report, Ponders Corner, Washington, February 1988. U.S. EPA contract no. 68-01-7251)

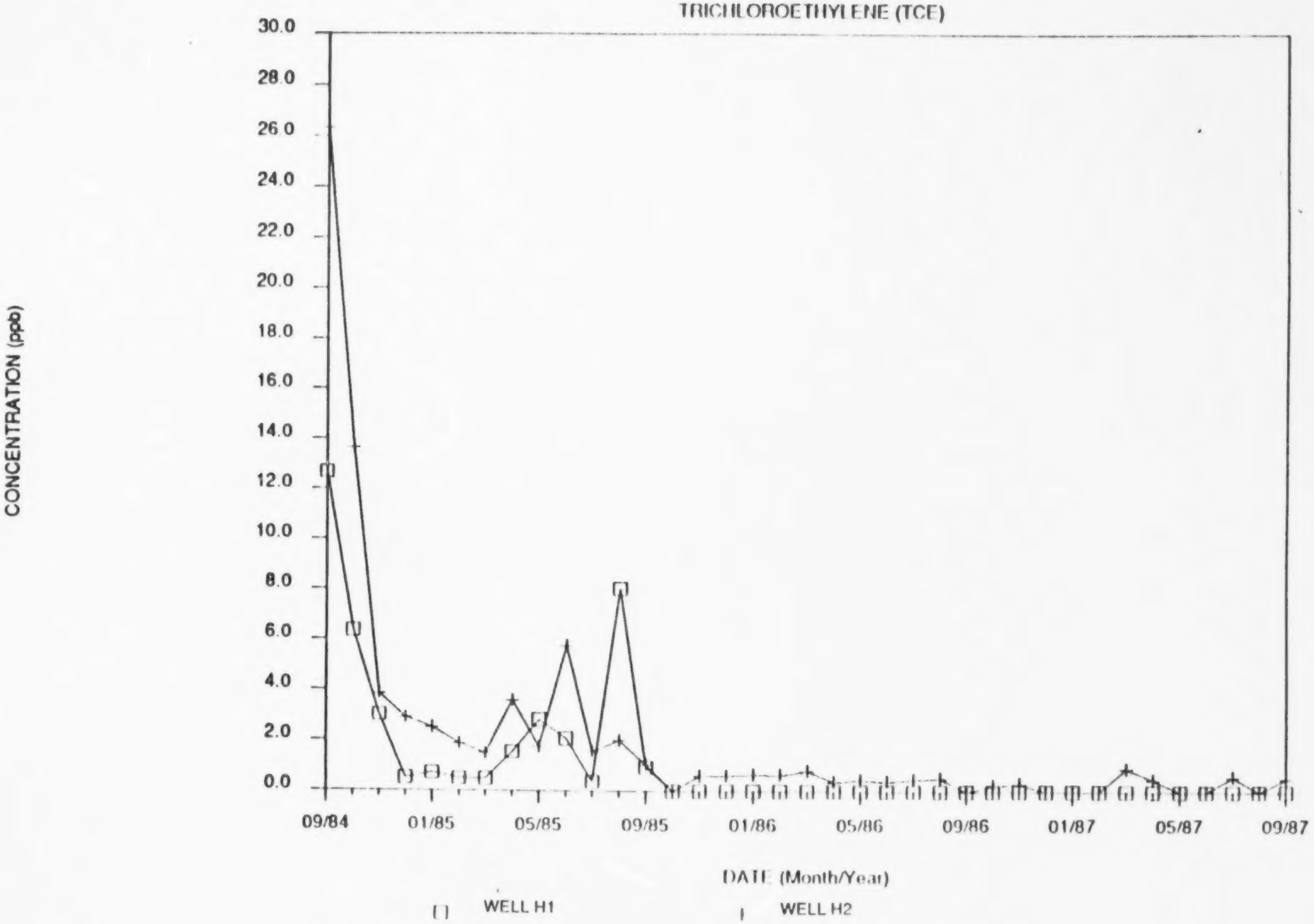

Figure 4. Trichloroethylene (TCE) concentrations of wells H1 and H2.

(Reference: CH_2M Hill, Final Aquifer Cleanup Assessment Report, Ponders Corner, Washington, February 1988. U.S. EPA contract no. 68-01-7251)

TABLE 1. CAPITAL COSTS FOR THE PONDERS CORNER GROUND WATER TREATMENT SYSTEM AND THE SOIL VACUUM EXTRACTION SYSTEM

1. Ground Water Treatment System

   a. Estimated Capital Costs (Source: EPA Feasibility Study, July 1985)

Item	Cost/1985 Basis
• Excavate and remove septic tanks and drain field	$253,450
• Install variable frequency controllers on well pumps	57,780
• Install fan speed reduction on treatment system	1,600
• Install two additional monitoring wells	22,140
	$334,970

   b. Approximate Actual Capital Cost (Source: Letter from Janet O'Hara, EPA Region 10 RPM)

• Construction Cost, Air Stripping System	$640,000

2. Soil Vacuum Extraction System

   a. Esimated Capital Costs (Source: EPA Feasibility Study, July 1985)

• Engineering and design	14,000
• Construction[a]	16,500
• Services during construction, including Health and safety Mobilization Bonds, insurance Contingencies	8,000
	$38,500

---

[a] Includes augering wells, vacuum pump, stack, and piping, less net salvage value of $10,000

TABLE 1 (continued)

b. Capital Cost Bid Tabulation
(Source: Ecova Corporation Proposal and Bid Documents, September 1987)

Item	Cost/1985 Basis
• Bond	2,700
• Insurance	0
• General requirements	17,000
• Trench excavation and backfill	2,500
• Mobilization and cleanup	2,000
• Drilling and sampling	1,800
• Well installation and completion	14,000
• Portable fire and safety equipment	500
• Activated carbon system	5,600
• Building	10,000
• Vapor extraction system	2,200
• Electrical	2,700
	$61,000

The estimated capital cost of the soil vacuum extraction system was $38,500 (EPA FS, July, 1985) and the capital cost bid tabulation was $61,000 (Ecova Corp. bid documents, October, 1987). The reasons for the differences in capital cost between estimates and bids are unknown.

Operation and maintenance costs associated with the ground water treatment system are shown in table 2. O&M cost data are not currently available for the soil vacuum extraction system. Annual O&M costs for the ground water system were initially estimated at $64,000 (Federal Assist. Application, July 1984). However, actual operating costs have been lower at $21,000 to $23,000 per year (R.G. Forster correspondence, May, 1989). Actual power costs have been consistent with projections. Much, if not all, of the apparent difference in estimated versus actual operating costs may be a result of bookkeeping procedures wherein costs are accounted for against the Lakewood Water District and not specified as separate charges against the remedial facilities. Batch versus continuous operation of either system would influence the actual costs, but that factor was not studied.

The present worth unit cost of the ground water system, assuming a 10 year life and 10 percent interest, is approximately 0.01¢/gallon. The accuracy of this estimated unit cost is uncertain because of concerns noted in the case disclaimer and in the text of the main report regarding data quality and completeness.

TABLE 2. ANNUAL OPERATION AND MAINTENANCE COSTS FOR THE PONDERS CORNER GROUND WATER TREATMENT SYSTEM

Estimated Costs
(Source: Federal Assistance Application, 7/20/84)

Item	Cost
• Wells and equipment	
Labor	$15,500
• Ground water treatment system	
Labor, O & M	6,700
Supervision/administration	7,200
Power	22,150
Chemicals	1,776
Laboratory analysis	8,500
Vehicle upkeep	2,500
	$64,326

Actual Costs
(Source: Letter from Robert G. Forster, Manager, Lakewood Water District)

	Cost by Year		
Item	1985-1986	1987	1988
• Power	32,259	19,906	21,398
• Equipment	1,392	-	-
• Labor	877	-	-
• Purchased Services (lab analysis)	6,321	1,620	1,620
• Insurance	170	-	-
	44,019	21,526	23,018

REFERENCES

1. CH_2M HILL, Public Comment Feasibility Study, Ponders Corner, Washington, EPA 112-0L22, July, 1985.

2. CH_2M, HILL, Final Aquifer Assessment Report, Ponders Corner, Washington, February, 1985.

3. CH_2M HILL, Operations Manual for Ponders Corner Well Field Treatment Facility, November, 1984.

4. Ecova Corp., Proposal and Bid Documents for Construction of Vapor Extraction System, Ponders Corner, Washington. October 9, 1987.

5. CH_2M HILL, Notice of Construction and Application for Approval to the Puget Sound Air Pollution Control Agency for a Soil Vapor Extraction/Carbon Adsorption System, December 7, 1987.

6. WDOE, Application for Federal Assistance for Ponders Corner/Lakewood Water District IRM Operation and Maintenance, First Year, July 20, 1984.

7. Lakewood SVES Operation Summary. Draft Memo dated April 25, 1989.

APPENDIX G

SYLVESTER (GILSON ROAD) SITE

Case Study of Ground Water Extraction
With Physical, Chemical and
Biological Treatment

DISCLAIMER

This case study was prepared based on data provided to Alliance Technologies Corporation by various sources. Alliance recognizes that significant data gaps and inconsistencies may exist in the case study because the degree of data quality and completeness could not be defined.

CASE SUMMARY OF THE SYLVESTER (GILSON ROAD) SITE

Introduction

Operation of a 300 gallon per minute ground water treatment system was initiated in April 1986 to remediate ground water contaminated with volatile and extractable organics and heavy metals. The treatment system is a combination of physical, chemical, and biological processes. A 20 acre slurry wall and impermeable cap were also constructed to isolate and contain the contaminant plume. Based on EPA's ROD, the estimated time of treatment system operation was 1.7 years, but the system remains in operation after three years since startup. As of March 1986, total expenses at the Sylvester site were $9.8 million, of which $ 4.8 million was for design and construction of the ground water treatment facility. Actual annual operation and maintenance costs were not available due to pending judicial review but were estimated at $1.9 million in an EPA Fact Sheet (May, 1986).

Site Description and Background

The Sylvester Site is located southeast of the City of Nashua, New Hampshire between Route 111 and Gilson Road as shown in Figure 1. Originally a sand borrow pit, the 6-acre site was used for illegal waste disposal starting in the late 1960s. Various materials were either buried or stored at the site including household refuse, demolition materials, sludges and hazardous liquid chemicals. The actual amount of hazardous waste disposed of at the site is unknown but there is documentation of 800,000 gallons of hazardous wastes disposed between January and October 1979.

A court order prohibiting the disposal of hazardous wastes at the site was issued in October 1979. During 1980, 1314 drums of waste were removed and disposed of offsite at approved hazardous waste disposal sites. Remedial investigations were conducted at the site to characterize the type and amount of contaminants present. The investigation concluded that the disposal of hazardous wastes at the site had contaminated the ground water with volatile and extractable organics and heavy metals. Highest concentrations of contaminants found in the ground water are listed in Table 1. A temporary ground water recirculation system was installed to control the migration of contaminants away from the site until a remedial alternative could be chosen, designed, and installed. In January 1982, a feasibility study identified five remedial alternatives for cleanup of the Sylvester site. The U.S. EPA issued a Record of Decision on July 29,1982 approving the installation of a slurry wall and surface cap. The ROD also approved the use of a ground water treatment system, but a specific treatment process was not selected in anticipation of pilot scale evaluations. A ground water remediation method for the site was selected and documented in a supplemental ROD issued August 22, 1983.

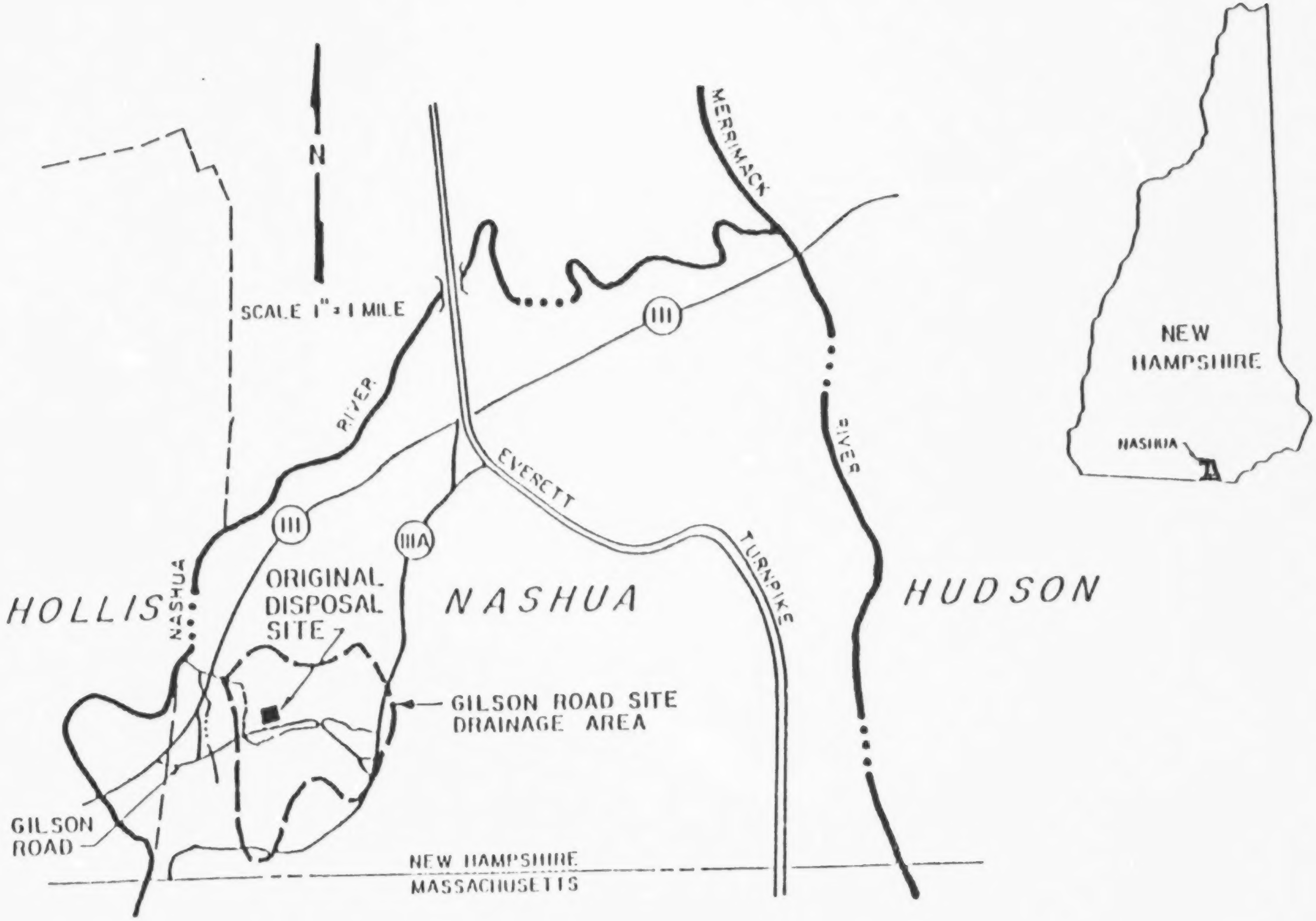
N
SCALE 1" = 1 MILE
MERRIMACK
RIVER
NASHUA
RIVER
111
111
111A
EVERETT
TURNPIKE
HOLLIS
NASHUA
HUDSON
ORIGINAL DISPOSAL SITE
GILSON ROAD SITE DRAINAGE AREA
GILSON ROAD
NEW HAMPSHIRE
MASSACHUSETTS
NEW HAMPSHIRE
NASHUA

Figure 1. Sylvester (Gilson Road) Location Map.

Source: Superfund Record of Decision (Supplement to 7/28/82 ROD), September 1983.

TABLE 1. HIGHEST CONCENTRATIONS OF CONTAMINANTS FOUND IN GROUND WATER AT SYLVESTER

	Concentration (ppb)
Vinyl Chloride	950
Benzene	3,400
Chloroform	31,000
1,1,2-Trichloroethane	17
Ethylene Chloride	73,000
Tetrachloroethylene	570
Trichloroethylene	15,000
Xylenes	10,000
Methyl Isobutyl Ketone	21,000
Methyl Ethyl Ketone	80,000
Chlorobenzene	1,100
Methylene Chloride	122,500
Toluene	29,000
Ethyl Benzene	1,200
1,1-Dichloroethane	15
t-1,2-Dichloroethane	18,000
1,1,1-Trichloroethane	2,000
Methyl Methacrylate	3,500
Ethyl Chloride	320
Tetrahydrofuran	1,500,000
2-Butanol	3,560
Dimethyl Sulfide	3,500
Diethyl Ether	20,000
Methyl Acetate	2,400
Isopropyl Alcohol	26,000
Acetone	310,000

Process Description

The initial ground water recirculation system was operated until October 1982 when construction of the 20-acre slurry wall and surface cap was completed. Ground water is extracted from eight wells as shown in Figure 2, and pumped to the 300 gpm ground water treatment facility.

The ground water treatment system utilizes four treatment steps to remove the contaminants present in the extracted ground water, as shown in Figure 3. The first step was designed to remove inorganic chemicals and heavy metals by using chemical reduction and precipitation methods. Lime is added to raise the pH of the feed water and precipitate metal contaminants. A settling tank and pressure filtration are used to further reduce particulate matter in the ground water. Volatile organic compounds are removed in the second step with a high temperature air stripper. Vapor exiting the stripper is burned in a fume incinerator to remove VOCs in the air stream. Wastewater from the air stripper is split into two streams. One stream, at 250 gpm, is recharged back into the contaminated site area while the second stream, at 50 gpm, undergoes biological treatment using an extended aeration, activated sludge process to remove soluble organics. This biologically treated stream is discharged onsite but outside of the slurry wall area. Treated water is returned to the ground through recharge trenches to flush contaminants out of the aquifer. All sludge developed by the treatment process is encapsulated onsite in the sludge disposal area.

Operational Data

Initially, a 100 gpm ground water extraction and treatment facility was specified for operation at Sylvester to remove 90 percent of the hazardous constituents. The system design load was increased to 300 gpm to account for a reduced operation time. It was estimated that at this flow rate, the ground water treatment system would be required to operate for 1.7 years to reach site specific cleanup standards. However, the ground water treatment facility has been in operation for over three years and a completion date is not known.

Performance Data

Monthly progress reports and performance evaluation documents have been unobtainable due to pending litigation between the PRPs.

Cost Data

The total estimated present worth cost of the initially proposed remedial action (20 acre slurry wall, surface cap, and 100 gpm treatment system) was $ 8,660,000 (U.S. EPA ROD, July 1982). This included a capital cost for the ground water treatment system of $ 6,788,000, and annual operation and maintenance costs of $ 750,000 for 6.2 years of operation. Eventually, a 300 gpm treatment process was agreed upon to reduce the planned operation time to 1.7 years. The estimated capital cost for the 300 gpm system was $ 4,696,400 with an annual operating expense of $ 1,380,000 (as shown in Tables 2 and 3, respectively). The estimated present worth cost of the system amounted to $7,097,000.

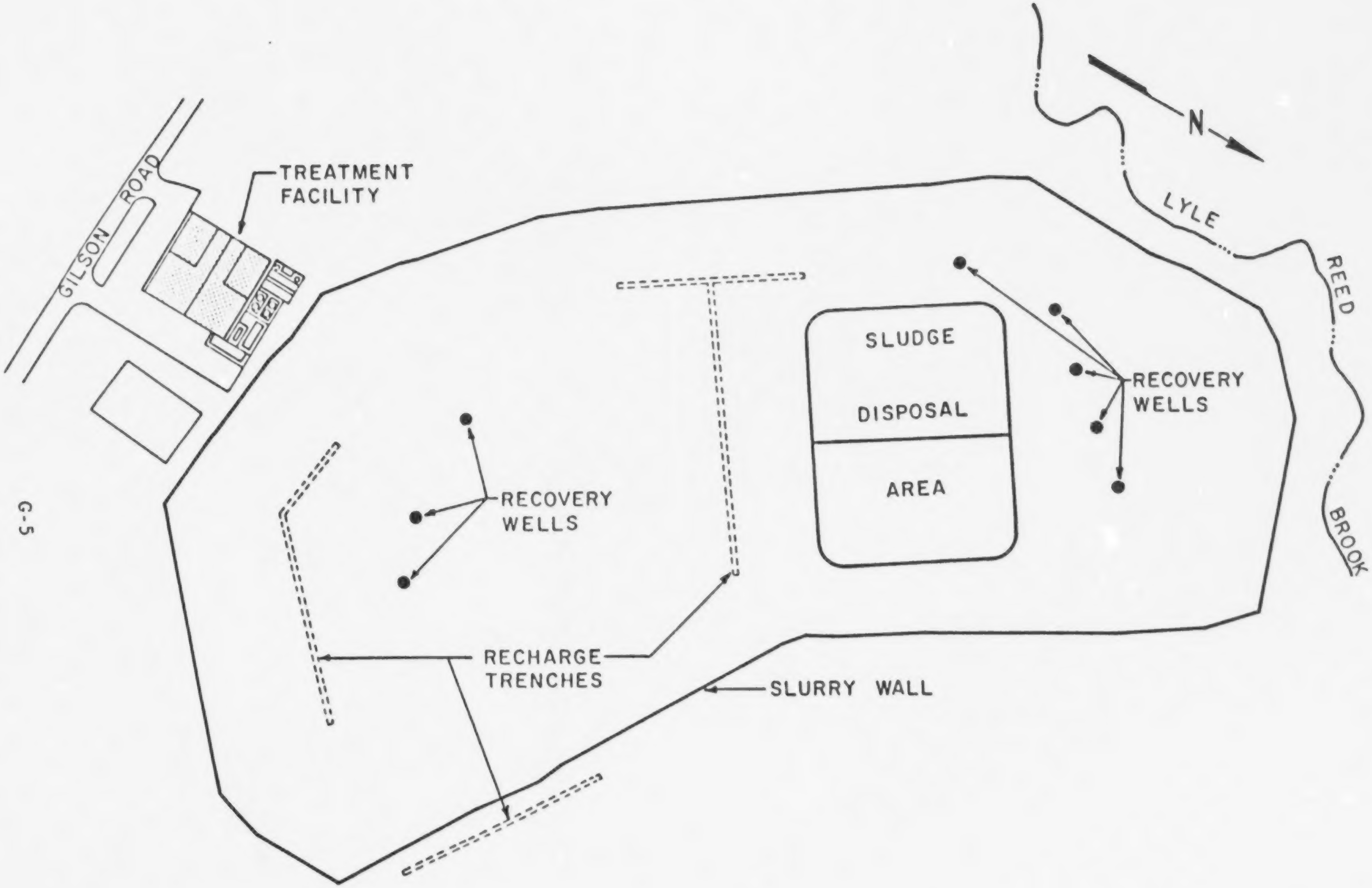
TREATMENT
FACILITY
GILSON ROAD
N
LYLE
REED
BROOK
SLUDGE
DISPOSAL
AREA
RECOVERY
WELLS
RECOVERY
WELLS
RECHARGE
TRENCHES
SLURRY WALL

Figure 2. Sylvester Ground Water Extraction and Treatment System.

Source: EPA Fact Sheet, May 1986.

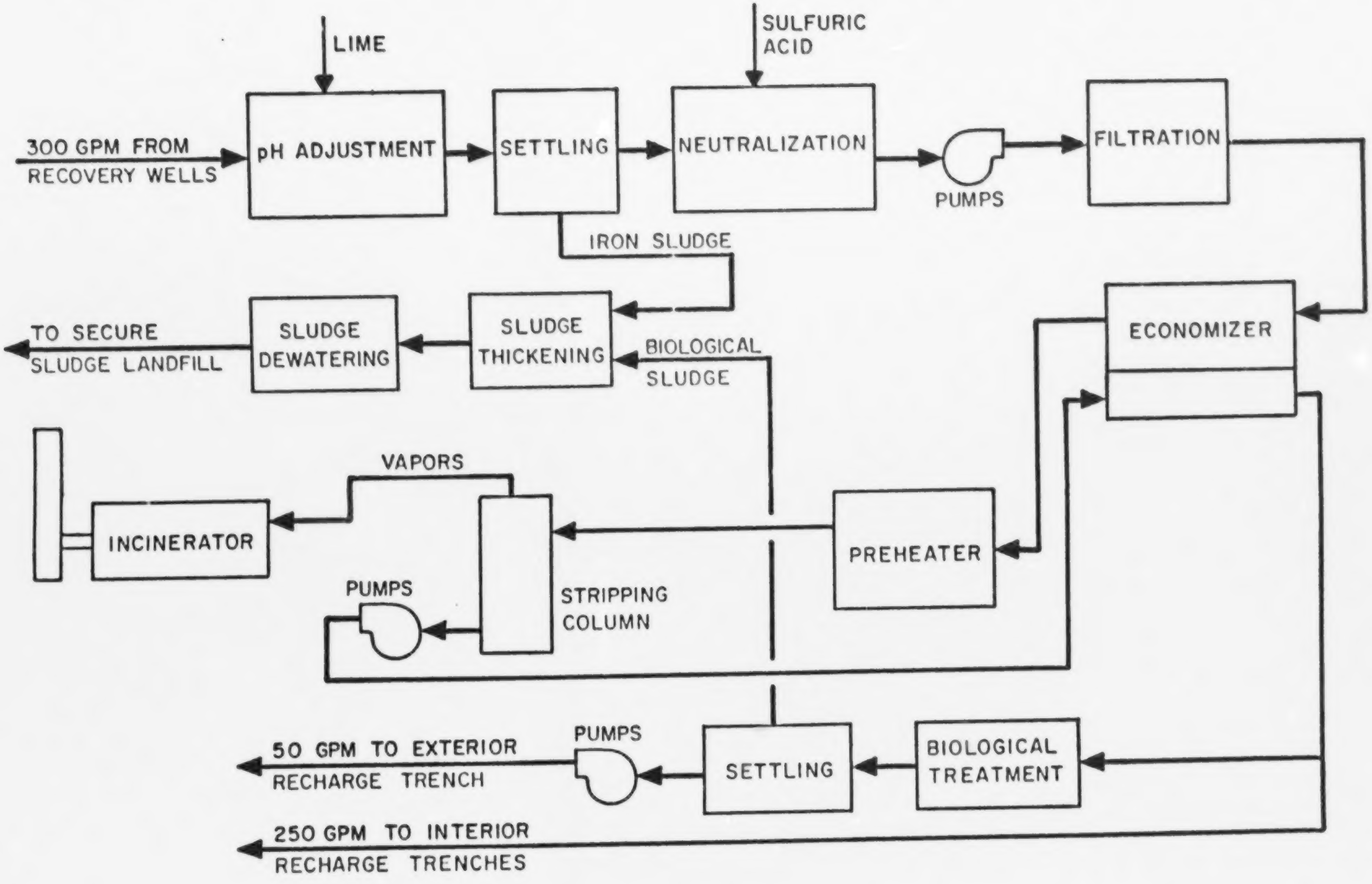
LIME
SULFURIC ACID
300 GPM FROM RECOVERY WELLS
pH ADJUSTMENT
SETTLING
NEUTRALIZATION
PUMPS
FILTRATION
IRON SLUDGE
ECONOMIZER
TO SECURE SLUDGE LANDFILL
SLUDGE DEWATERING
SLUDGE THICKENING
BIOLOGICAL SLUDGE
VAPORS
INCINERATOR
PREHEATER
PUMPS
STRIPPING COLUMN
50 GPM TO EXTERIOR RECHARGE TRENCH
PUMPS
SETTLING
BIOLOGICAL TREATMENT
250 GPM TO INTERIOR RECHARGE TRENCHES

Figure 3. Process Flow Diagram of the Sylvester Ground Water Extraction and Treatment System.

Source: EPA Fact Sheet, May 1986.

TABLE 2. ESTIMATED CONSTRUCTION COSTS FOR THE SYLVESTER GROUND WATER TREATMENT SYSTEM[a]

ITEM	CAPITAL COST
1. Construction of treatment building, site work, utilities, and sludge disposal site	$ 985,000
2. Chemical precipitation, neutralization, sludge dewatering	635,000
3. High temperature air stripping, incineration, and compliance testing	622,000
4. Extraction and recharge system	475,000
5. Package extended-aeration, activated-sludge plant with nutrient addition to treat purge stream	340,000
6. Electrical, instrumentation, piping, and HVAC	875,000
Subtotal	$3,914,000
7. Contingencies (20%)	782,400
Total Capital Cost	$4,696,400

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[a] Source: U.S. EPA ROD, September 1983.

TABLE 3. ESTIMATED ANNUAL OPERATIONAL COSTS FOR THE 300gpm TREATMENT SYSTEM AT THE SYLVESTER SITE[a]

ITEM	COST
1. Labor	$ 262,200
2. Electricity	69,000
3. Fuel Oil	883,000
4. Chemicals	96,800
5. Sludge Disposal (on-site)	41,400
6. Maintenance Materials	13,800
7. Miscellaneous (Insurance, Phones, etc.)	13,800
Total	$1,380,000

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[a] Source: U.S. EPA ROD, September 1983

As of March 1986, $9.8 million had been spent for remedial activities at the Sylvester site (EPA Fact Sheet, May 1986). This included $4.8 million spent on the design and construction of the treatment facility. As shown in Table 4, there were other expenses related to the treatment system installation, including administrative and oversite costs. After completion of the ground water treatment facility, annual operation and maintenance costs were re-estimated at $1.9 million. Actual annual operation and maintenance costs are undergoing judical review and are not currently available due to pending litigation.

As of March 1986, $9.8 million had been spent for remedial activities at the Sylvester site (EPA Fact Sheet, May 1986). This included $4.8 million spent on the design and construction of the treatment facility. As shown in Table 4, there were other expenses related to the treatment system installation, including administrative and oversite costs. After completion of the ground water treatment facility, annual operation and maintenance costs were re-estimated at $1.9 million. Actual annual operation and maintenance costs are undergoing judical review and are not currently available due to pending litigation.

TABLE 4. SYLVESTER EXPENSES AS OF MARCH 31, 1986[a]

ITEM	GRANT AMOUNT	AMOUNT SPENT
Current Expense	$ 40,531	$ 24,446
Equipment	25,300	10,248
Travel	39,175	25,988
Contractual		
Slurry Wall Design	216,000	215,086
Feasibility Study	118,600	118,600
Pilot Plant Study	374,805	374,800
Treatment Plant Design	308,300	291,200
OSC/Resident Eng.	234,790	225,392
Hydrogeological Invest.	60,000	60,000
Construction Admin.	453,400	364,831
Plant O&M	1,059,541	42,348
Subtotal	3,059,825	1,692,257
Construction		
Slurry Wall Const.	2,454,100	2,431,164
Const. Overview	116,287	105,912
Treatment Plant Const.	5,375,000	4,456,626
Contingency	268,750	133,707
Subtotal	8,214,137	7,127,409
Other		
Water Line	118,987	118,987
Community Relations	10,200	1,911
Eminent Domain	150,000	124,889
Site Monitoring	61,800	0
Admin. & Audit	11,450	5,573
Air Monitoring	17,800	0
Subtotal	370,237	251,359
Indirect Cost	15,387	3,698
TOTAL	$11,528,422	$9,834,093

[a] Source: EPA Fact Sheet, May, 1986

REFERENCES

1. U.S. EPA. Superfund Record of Decision, Sylvester Site, NH. EPA/ROD/R01-82/005. July, 1982.

2. U.S. EPA. Superfund Record of Decision, Sylvester Site, NH (Supplement to 07/29/82 ROD). EPA/ROD/R01-83/007. September, 1983.

3. U.S. EPA. Fact Sheet. Gilson Road (Sylvester) Hazardous Waste Site. Nashua, NH. May, 1986.

4. Telephone Conversations between Brian Schmoyer, Alliance, and Chester Janowski, RPM, EPA Region 1. 1989.

APPENDIX H

UNITED CHROME PRODUCTS SITE

Case Study of Chemical Treatment of Ground Water and Soil Flushing

DISCLAIMER

This case study was prepared based on data provided to Alliance Technologies Corporation by various sources. Alliance recognizes that significant data gaps and inconsistencies may exist in the case study because the degree of data quality and completeness could not be defined.

CASE SUMMARY OF THE
UNITED CHROME PRODUCTS SITE

Introduction

Operation of a ground water treatment system at the United Chrome Products site near Corvallis, Oregon began in August, 1988 for the removal of hexavalent chromium from an estimated 2.4 million gallons of contaminated ground water. Contaminated soil is flushed using two infiltration basins resulting from the excavation of 1,100 tons of soil in areas with the highest measured levels of chromium contamination. Ground water is extracted from 23 wells and treated using a packaged chemical reduction and precipitation system. The method of soil and ground water remediation was selected due to several factors: 1) chromium is amenable to soil flushing; 2) chemical reduction/precipitation is a well demonstrated and relatively simple treatment for chromium-contaminated water; and 3) the perceived ability of the chosen method to clean-up the site to pre-existing conditions. Project completion time is yet to be decided based on operating results but is forecasted to be from five to twenty-five years. The total capital cost incurred at the United Chrome Products site as of the end of 1988, was $2,398,500. First year operating costs have been estimated at almost $153,000 for the treatment system operating at 30 percent capacity.

Site Description and Background

The United Chrome Products (UCP) site is a former chrome plating facility located south of the City of Corvallis, Oregon. All land at and surrounding the site has been owned, since 1948, by the City of Corvallis. Surface water drainage is collected by a ditch along the northern side of the property. The ditch drains into the Dry Creek which eventually drains into the Williamette River, a city water source.

The site subsurface consists of two saturated zones separated by a confining silty clay layer. Ground water in both the upper unconfined zone and the lower confined aquifer as well as the soil underlying the area is contaminated with hexavalent chromium. Chromium levels in ground water sampled from the contamination plume in the upper unconfined zone have been measured as high as 14,600 mg/L near the plating tanks and 142 mg/L at an outlying monitoring well. Analysis of ground water taken from the lower confined aquifer shows chromium levels as high as 19 mg/L. The UCP site area and the lateral extent of contamination in the unconfined and confined zones are shown in figures 1 and 2, respectively.

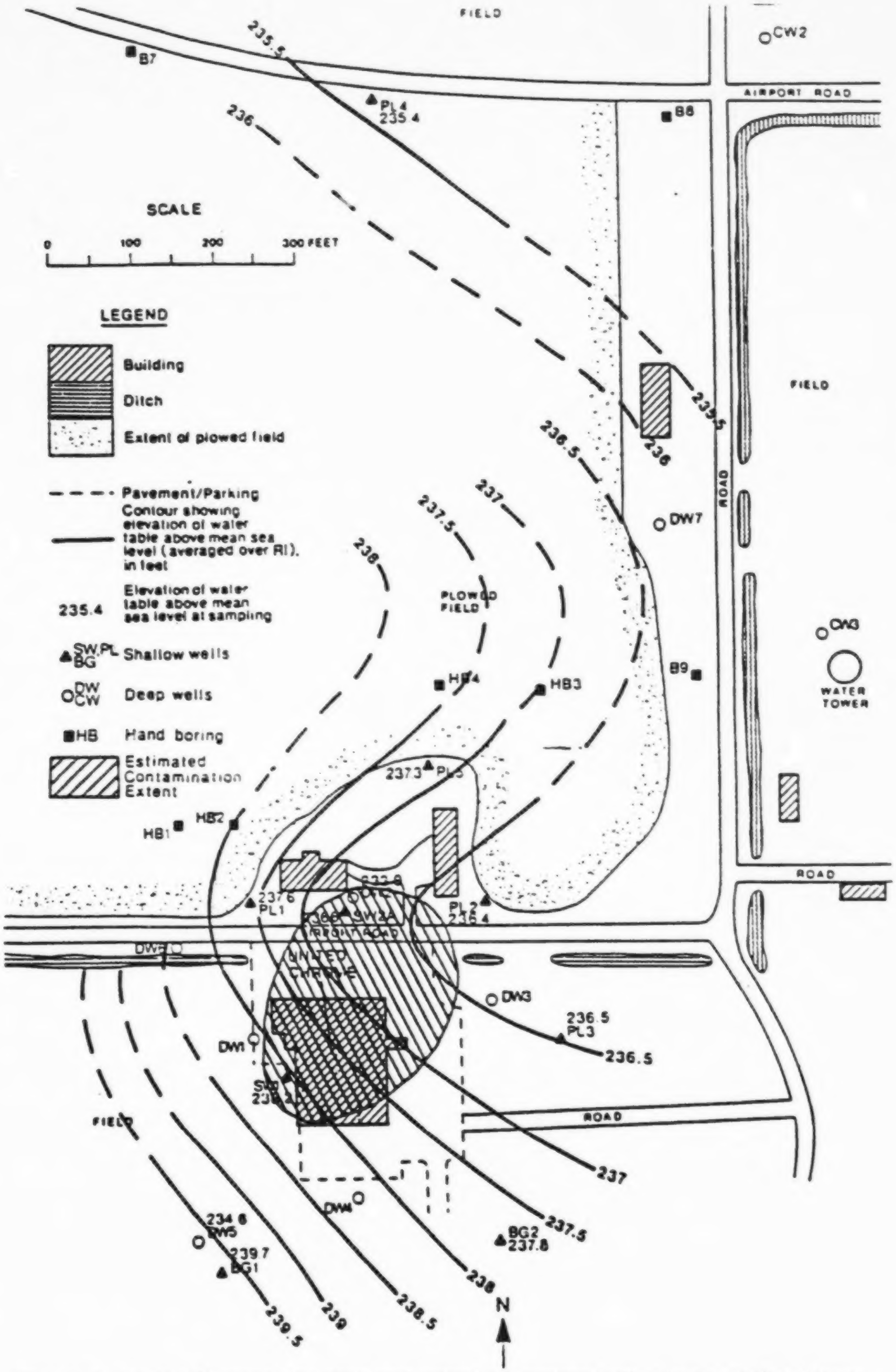
FIELD
CW2
B7
235.5
AIRPORT ROAD
PL4
235.4
B8
236
SCALE
0
100
200
300 FEET
LEGEND
Building
Ditch
Extent of plowed field
Pavement/Parking
Contour showing elevation of water table above mean sea level (averaged over RI), in feet
235.4
Elevation of water table above mean sea level at sampling
SW,PL BG
Shallow wells
DW CW
Deep wells
HB
Hand boring
Estimated Contamination Extent
FIELD
235.5
236
236.5
ROAD
237
237.5
DW7
238
PLOWED FIELD
CW3
B9
WATER TOWER
HB4
HB3
237.3
PL5
HB1
HB2
237.6
PL1
PL2
236.4
SW2A
FRONT ROAD
ROAD
DW2
UNITED CHROME
DW3
236.5
PL3
236.5
DW1
SW
ROAD
FIELD
237
DW4
237.5
BG2
237.8
234.6
DW5
239.7
BG1
238
N
239.5
239
238.5

Figure 1. United Chrome site area and extent of contamination in unconfined zone.

(Reference: United Chrome Products, U.S. EPA Record of Decision, Sept. 1986)

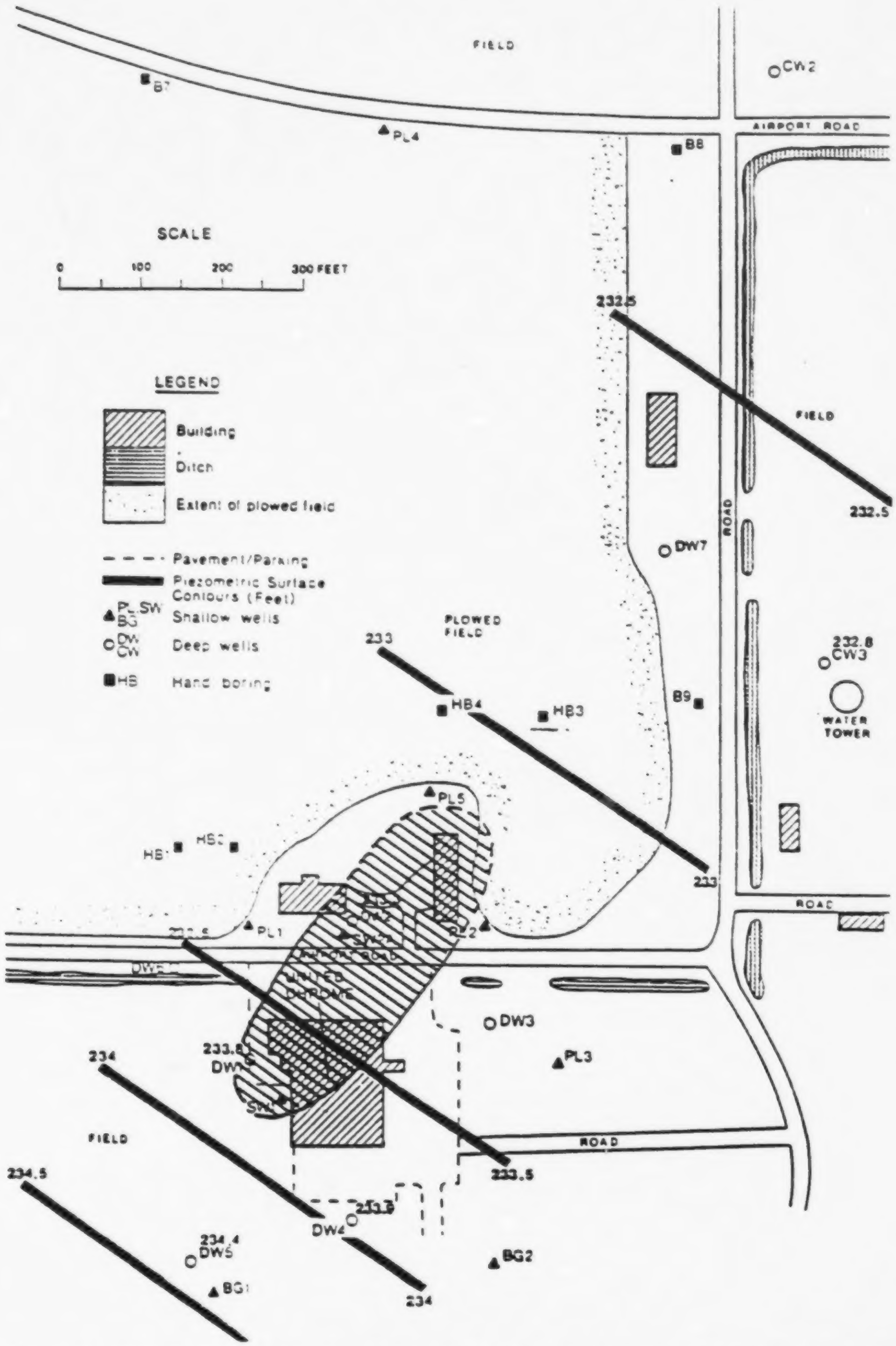
FIELD
CW2
B7
PL4
AIRPORT ROAD
B8
SCALE
0
100
200
300 FEET
232.5
LEGEND
Building
Ditch
Extent of plowed field
Pavement/Parking
Piezometric Surface Contours (Feet)
PL SW BG Shallow wells
DW CW Deep wells
HB Hand boring
FIELD
232.5
ROAD
DW7
PLOWED FIELD
233
HB4
HB3
B9
232.8
CW3
WATER TOWER
PL5
HB2
HB1
233
ROAD
PL1
PL2
AIRPORT ROAD
UNITED CHROME
DW1
233.5
DW3
PL3
234
233.8
DW2
SW
FIELD
ROAD
233.5
234.5
233.9
DW4
234.4
DW5
BG1
BG2
234

Figure 2. United Chrome site area and extent of contamination in confined aquifer.

(Reference: United Chrome Products, U.S. EPA Record of Decision, Sept. 1986)

United Chrome Products had been electroplating at the present site since 1956. Between 1956 and 1975, an estimated 1,000 gallons per year of product washings and rinsates collected from a sump were dumped to a dry well disposal pit located west of the UCP building which resulted in hexavalent chromium contamination. This disposal practice was reportedly stopped in 1975. Other chromium contamination occurred due to a leaking plating tank. UCP ceased all operations at the site in early 1985 and sold all their equipment and materials. As a result of an immediate removal action initiated in July, 1985, spent plating solutions and drums containing waste were removed from the site. A remedial investigation and feasibility study was completed in August, 1985. On September 12, 1986, a Record of Decision (ROD) was signed.

The selected remedial method consisted of the following actions:

- Installation of approximately 15 shallow wells to extract contaminated ground water in the upper unconfined ground water zone.
- Installation of approximately 5 deep wells to extract ground water in the lower confined aquifer.
- Installation of an onsite ground water treatment facility.
- Excavation of approximately 350 tons of soil for the construction of two percolation basins to flush contaminated soil.
- Installation of culverts to isolate the surface drainage system from the inflow of contaminated surface water and ground water from the site.

Process Description

The remedial action was divided into two phases. Phase One focused first on eliminating contamination in the upper unconfined region where concentrations of chromium were greatest. Shallow extraction wells were installed to remove contaminated ground water from the upper subsurface region. A ground water treatment facility, utilizing a packaged chemical reduction and precipitation system for the removal of chromium, was constructed and installed onsite in the existing UCP building. Approximately 1,100 tons of chromium-containing soil was excavated and disposed of offsite. The resulting pits from the excavations were used as infiltration basins to flush the remaining contaminated soil.

The second phase of the operation is aimed at cleaning the lower confined aquifer by installing deep ground water extraction wells which will be added to the current treatment system. Also, the installation of culverts in the contaminated local drainage system is to be conducted. The design and construction of Phase Two will be implemented after evaluation of Phase One.

For Phase One, 23 extraction wells are used to extract and transfer contaminated ground water to the site treatment system, which is presently operated by the City of Corvallis. The shallow extraction wells were placed 50 to 60 feet apart and were installed at a depth of 20 feet.

At the treatment plant, sulfuric acid and sodium bisulfite are added to the ground water to reduce the hexavalent chromium present in the water to its trivalent state. The ground water treatment process flow diagram is shown in figure 3. Sodium hydroxide is added to the solution to precipitate the chromium as an insoluble hydroxide. A flocculent is added to the mixture to enhance settling of the chromium hydroxide sludge. Accumulated sludge is withdrawn and pumped to a filter press for dewatering. The sludge is disposed of at a hazardous waste disposal facility. Treated ground water is discharged to the City of Corvallis wastewater treatment plant.

Operational Data

The ground water extraction system began operation on August 15, 1988. Between August 15, 1988 and February 28, 1989, the 23 extraction wells pumped 314,731 gallons of chromium-contaminated ground water to the treatment system at an average combined rate of 10.5 gpm. Due to a limited operating schedule and insufficient sludge processing capacity, the ground water extraction and treatment system has been operating below design throughputs. Extraction of ground water has averaged 3,421 gallons per operating day which is 30 percent of the assumed daily extraction capacity of 11,500 gpd. A summary of extraction system data taken from "Performance Evaluation of the United Chrome Ground Water Extraction and Treatment Facility, April, 1989" is provided in table 1.

The ground water treatment system has processed 691,030 gallons through February 28, 1989. This volume includes extracted ground water, dilution, and recirculation water. The average treatment system flow rate was 27 gpm with the system operating an average of 4.7 hours per day. With the correction of the sludge processing problem, the treatment system is expected to operate 8 hours per day at 25 gpm for inlet chromium concentrations at or below 800 mg/L. The total volume of water treated would be 12,000 gpd. Actual process treatment rates will depend on influent chromium concentrations. A summary of treatment system data taken from "Performance Evaluation of the United Chrome Ground Water Extraction and Treatment Facility, April, 1989" is listed in table 2.

Tentative estimates for phase one cleanup time is 1 to 2 years to reach ground water equilibrium concentrations of 100 mg/L, but an additional 3 to 25 years of operation may be required to reduce chromium concentrations to the cleanup criterion of 10 mg/L.

Performance Data

Average monthly hexavalent chromium concentrations of the extracted ground water decreased from 1,923 mg/L in August, 1988 to 1,110 mg/L for January, 1989. During this period, an estimated 3,965 pounds of chromium were removed from the aquifer by the extraction system.

Average monthly hexavalent chromium concentrations of the treatment system influent fluctuated between 815 mg/L in October 1988 to 483 mg/L in January 1989. All monthly chromium concentrations of the treatment system effluent were at or below the discharge standard of 1.70 mg/L total Cr. Average monthly removal efficiencies were in excess of 99.7 percent. A total of 890 ft^3 of sludge was produced from start up in August 1988 to the end of February 1989.

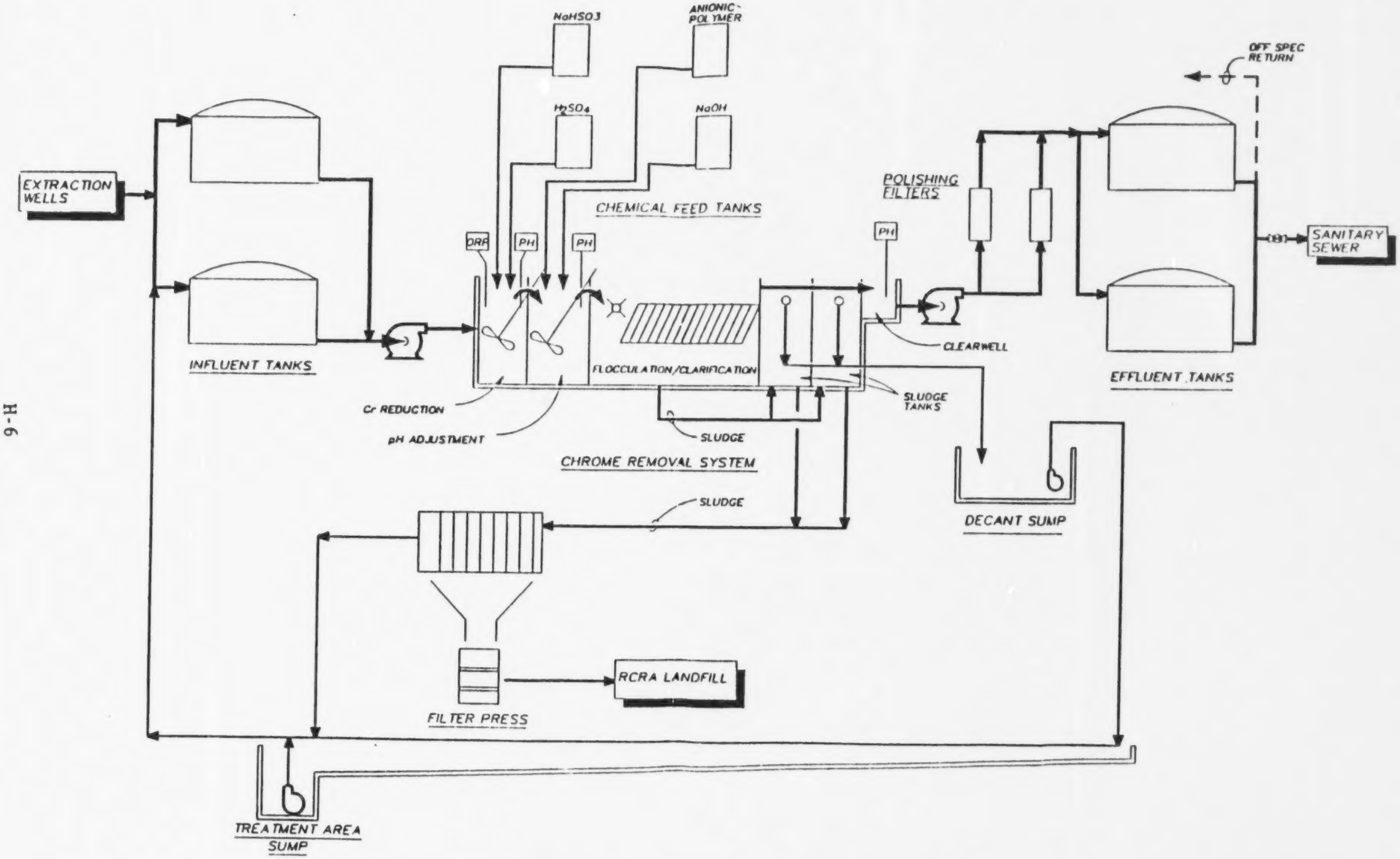
NaHSO3
ANIONIC-POLYMER
OFF SPEC RETURN
H2SO4
NaOH
EXTRACTION WELLS
POLISHING FILTERS
CHEMICAL FEED TANKS
ORP
PH
PH
PH
SANITARY SEWER
CLEARWELL
INFLUENT TANKS
FLOCCULATION/CLARIFICATION
EFFLUENT TANKS
Cr REDUCTION
SLUDGE TANKS
pH ADJUSTMENT
SLUDGE
CHROME REMOVAL SYSTEM
SLUDGE
DECANT SUMP
RCRA LANDFILL
FILTER PRESS
TREATMENT AREA SUMP

Figure 3. Process flow diagram for United Chrome ground water treatment system.

Reference: CH_2 M Hill, performance evaluation at the United Chrome ground water extraction and treatment facility, April 1989.

TABLE 1. EXTRACTION SYSTEM DATA SUMMARY*

Month	Days in month	Days onsite[a]	Pumping hours[b]	Gallons pumped	Gallons recharged[c]	Average extraction[d] rate (gpm)	Pounds Cr VI removed[e]	Average Cr VI concentration[f] (mg/L)	Cr VI pounds per 1,000 gal extracted
1988									
August	16	10	29.0	15,523	0	8.9	249	1,923	16.0
September	30	16	159.0	70,044	146,594	7.3	924	1,573	13.2
October	31	17	97.0	61,353	85,415	10.5	773	1,512	12.6
November	30	17	83.8	62,139	7,200	12.3	800	1,543	12.8
December	31	16	71.3	55,560	0	13.0	755	1,629	13.6
1989									
January	31	16	58	50,112	0	14.5	464	1,110	9.3
February[g]	28	0	0	0	0	0	0	0	0
	—	—	—	—	—	—	—	—	—
Totals	197	92	498.1	314,731	239,209		3,965		

---

[a] Total days in month with operators onsite for 10-hour shift.
[b] Total hours of extraction system operation.
[c] Gallons of recharge water added to infiltration basin.
[d] Average flow from extraction wells during pumping.
[e] Estimate of Cr VI removed from aquifer.
[f] Average Cr VI concentration of extracted ground water.
[g] Treatment plant shut down for repair due to frozen pipes.
*Reference: CH2M HILL, Performance Evaluation of the United Chrome Ground Water Extraction and Treatment Facility, April, 1989.

TABLE 2. TREATMENT SYSTEM DATA SUMMARY*

Month	Days in month	Days onsite[a]	Treatment system hours[b]	Total gallons treated[c]	Total gallons discharged[d]	Treatment rate[e] (gpm)	Average influent conc. Cr VI (mg/L)[f]	Average effluent conc. Total Cr (mg/L)[g]	Sludge (ft^3)
1988									
August	16	10	33.4	45,820	13,390	22.9	630	1.02	0
September	30	16	113.0	153,090	75,390	22.6	724	0.61	218
October	31	17	53.6	113,660	64,360	35.3	815	1.00	174
November	30	17	87.1	137,550	55,050	26.3	697	1.32	186
December	31	16	71.1	125,700	72,370	29.5	720	1.47	174
1989									
January	31	16	70.1	115,210	59,840	27.4	483	1.70	138
February[h]	28	0	0	0	0	0	0	0	0
	197	92	428.3	691,030	340,400[g]				890

[a] Total days in month with operators onsite for 10-hour shift.

[b] Total hours of treatment system operation.

[c] Total gallons through treatment process including ground water, dilution, and recirculation water.

[d] Total gallons discharged to the City of Corvallis Wastewater Treatment Plant.

[e] Average treatment rate through system.

[f] Influent concentration after dilution.

[g] The discrepancy between total gallons discharged and gallons pumped from extraction wells can be attributed to the treatment of construction generated wastewaters, and washdown and rainwater from the treatment area.

[h] Treatment plant shut down for repair due to frozen pipes.

*Reference: CH2M HILL, Performance Evaluation of the United Chrome Ground Water Extraction and Treatment Facility, April 1989.

Cost Data

The total capital cost estimate for the entire remediation project (Phases One and Two) in the ROD was $1,580,000 as shown in table 3. The total annual operating costs are listed in table 4 and were estimated at $261,000. The total project present worth assuming a 5-year life at 10 percent interest was $2,570,000.

The original work plan budget (bid cost) totaled $1,510,055, including construction and operation contracts as well as construction management for the completion of Phase One of the remediation project. An operations contract of $63,000 was included in the initial work plan cost, but was not awarded because the City of Corvallis agreed to operate the facility (see table 3).

The actual costs of the UCP facility have been updated through several work plan revisions. The latest revision, No. 7, dated December 30, 1988, totaled $2,398,511 and included capital costs for Phase One construction, project management, and operations oversight as shown in table 4. Actual operating costs for the ground water extraction and treatment facility could not be obtained but have been estimated by CH_2M Hill at $12,750/month or $153,000/year under the current plant operating capacity of 30 percent (see table 5).

As previously mentioned, the original Phase One Work Plan was revised several times to incorporate changes in the scope of the work plan. Subtasks that were added to the original work plan include: quality control, technical and EPA negotiation support, development of O&M manuals, and performance and data evaluation. Also, additional funding was added to the Phase One Work Plan to allow CH_2M Hill to perform ongoing essential subtasks until approval of the Phase Two Work Plan. Subtasks that were added or allotted additional funding included Phase Two Work Plan development and project management.

Unit costs are estimated as roughly 16¢/gallon using the cost information provided, an interest rate of 10 percent, and assuming that the system operates for a period of 5 years; 2 years at 30% plant efficiency and 3 years at 70% plant efficiency. The accuracy of this estimated unit cost is uncertain because of concerns noted in the case disclaimer and in the text of the main report regarding data quality and completeness.

TABLE 3. ESTIMATED CAPITAL COSTS FOR THE UNITED CHROME PRODUCTS SITE[a]

	Estimated Cost
General Mobilization, Bonding, Insurance Health and Safety Program Equipment Decontamination Equipment Demobilization	$ 51,000
Unconfined Zone Ground Water Extraction	46,000
Confined Aquifer Ground Water Extraction	24,000
Onsite Wastewater Treatment	682,000
Effluent Disposal	137,000
Demolition	32,000
Soil Excavation/Disposal	48,000
Soil Flushing	3,000
Surface Drainage	10,000
Construction Subtotal	1,033,000
Bid Contingencies (15%)	155,000
Scope Contingencies (15%)	155,000
Construction Total	1,343,000
Permitting and Legal (3%)	31,000
Services During Construction (10%)	103,000
Total Implementation Cost	1,477,000
Engineering Design (10%)	103,000
TOTAL CAPITAL COST[b]	$ 1,580,000

[a] Source: U.S. EPA, Record of Decision, Remedial Alternative Selection, United Chrome Products, September 12, 1986

[b] Estimated and actual costs cover varying tasks; major differences are discussed in the cost section of the text

TABLE 4. ACTUAL CAPITAL COSTS FOR THE UNITED CHROME PRODUCTS SITE[a]

	Cost ($)
Construction Contract	
Base Price of Contract	554,413
Hazardous Waste Disposal	257,621
Extraction Wells	123,556
Dust Control	11,720
Contract Revisions	401,791
Scope Contingency	100,000
Subcontract fee	72,455
Construction Subtotal	1,521,556
Wastewater Treatment System	157,500
Operations Oversight During Start-up	10,000
Other Equipment and Supplies	100,000
Construction Management	
EPA Work Plan	5,703
Project Management	66,809
Project Planning	28,349
Quality Control	25,432
Bid and Award	35,270
Detailed Inspection	138,197
Cleanup Validation	54,705
Other Engineering Service	93,742
O & M Manuals	19,200
Technical Support	28,167
EPA Negotiation Support	6,018
Performance Evaluation	24,120
Nonroutine Maintenance	26,408
Data Evaluation	34,487
Project Closeout	22,858
Subtotal	609,465
TOTAL CAPITAL COSTS[b]	2,398,511

[a] Source: CH2M HILL, United Chrome Products, Work Plan Revision No. 7, Dec. 30, 1988

[b] Estimated and actual costs cover varying tasks; major differences are discussed in the cost section of the text

TABLE 5. OPERATION AND MAINTENANCE COSTS FOR THE UNITED CHROME PRODUCTS GROUND WATER EXTRACTION AND TREATMENT FACILITY.

ESTIMATED O & M COSTS[a]

	Estimated Annual Cost ($)
Administration	42,000
Operations	96,000
Maintenance	36,000
Disposal	20,000
Sample Analysis	24,000
O & M Subtotal	218,000
Contingencies (20%)	43,000
TOTAL ANNUAL OPERATING COST	261,000

ACTUAL O & M COSTS[b,c]

	Monthly Cost ($)	Annual Cost
Operating Labor	7,830	93,960
Materials and Labor	0	0
Power and Water	100	1,200
Chemicals	958	11,496
Personal Protective Equipment	140	1,680
Purchased Services	0	0
Analytical	100	1,200
Disposal	1,651	19,812
Administrative	1,958	23,496
Insurance Taxes and Licenses	0	0
Maintenance Reserve and Contingency Costs	0	0
Other Costs	12	144
TOTAL MONTHLY OPERATING COSTS[a]	12,749	152,988

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[a] Source: U.S. EPA, Record of Desicision, Remedial Alternative Selection, United Chrome Products, September 12, 1986.

[b] Actual O&M costs are based on present facility operating conditions. The facility is currently operating at 30 percent capacity.

[c] Provided by CH2M Hill, May 26, 1989.

REFERENCES

1. U.S. EPA, Record of Decision United Chrome Products Site, September 12, 1986.
2. CH_2M Hill, Remedial Action Work Plan, United Chrome Products, Contract No. 68-01-7251, December 10, 1988.
3. CH_2M Hill, Remedial Action Work Plan, United Chrome Products, Contract No. 68-01-7251, April 12, 1988.
4. CH_2M Hill, Remedial Action Work Plan, United Chrome Products, Contract No. 68-01-7251, November 6, 1987.
5. CH_2M Hill, Operation and Maintenance, United Chrome Products Monthly Costs.
6. CH_2M Hill, Technical Memorandum to EPA-Region 10, April 15, 1988.
7. CH_2M Hill, United Chrome Progress Report No. 2, January 24, 1989.
8. CH_2M Hill, Performance Evaluation of the United Chrome Ground Water Extraction and Treatment Facility, April, 1989.
9. U.S. EPA Region 10, Superfund Branch, Seattle, Washington, Telephone Discussions, December, 1988 and March 1989.

APPENDIX I

WESTERN PROCESSING
KENT, WASHINGTON

Case Study of Ground Water Extraction and Treatment

DISCLAIMER

This case study was prepared based on data provided to Alliance Technologies Corporation by various sources. Alliance recognizes that significant data gaps and inconsistencies may exist in the case study because the degree of data quality and completeness could not be defined.

CASE STUDY FOR THE WESTERN PROCESSING SITE

Introduction

The Western Processing Site Remedial Action began in June 1983 to mitigate soil, surface water and ground water contamination from heavy metals, VOCs, organics (including PAHs) and dioxin. The remedial treatment consists of containment, excavation, and surface infiltration of the soil vadose zone to allow flushing through the use of extraction pumps. Special treatments include air stripping, activated carbon adsorption, incineration, chemical oxidation/reduction and heavy metal precipitation followed by sludge dewatering. The treatment facility will operate for an estimated seven years. As of July, 1989, the EPA RPM estimated that the PRP had expended a total of $60,000,000 for site remediation.

Site Description and Background

Western Processing Inc. was a waste reclamation facility that reclaimed or converted industrial wastes during the period from approximately 1960 to 1983. The facility is located on a 13 acre site at 7215 South 196th Street, Kent, Washington in the Green River Valley. Figure 1 is a vicinity map taken from the Executive Summary Feasibility Study submitted in March 6, 1985. Western Processing Inc. has been under investigation for spills by both the State of Washington Department of Ecology and the Kent Fire Department prior to the EPA's administrative order ceasing all operations in 1983. A total of 90 priority pollutants have been detected in either soil, ground water, or surface water samples taken onsite. In addition to onsite contamination, there is also contamination in sediments taken from Mill Creek which borders the Western Processing Site.

Various governmental agencies in addition to the PRPs have been involved with the Western Process site cleanup since 1983. Table 1 lists in chronological order the various remedial actions taken and the agency responsible for the program.

The PRPs estimate that over 2400 truckloads of wastes were removed offsite during Phase I. A storm water collection and treatment system was also installed on site during Phase I and the treated effluent was discharged under permit to the local POTW.

The final task of Phase I was to remove oily water contaminated with dioxin. A new mobile treatment technology called K-peg which utilizes potassium polyethylene glycol was used at the site to chemically destroy dioxin. The system has also been used to detoxify dioxin at other sites.

Phase II subsurface remediation was preceded by an extensive well monitoring program. It was determined that excavation of contaminated soil was necessary to facilitate ground water cleanup. A total of 21,000 cubic yards of contaminated material was disposed of at the Arlington, Oregon, EPA-approved, hazardous waste landfill.

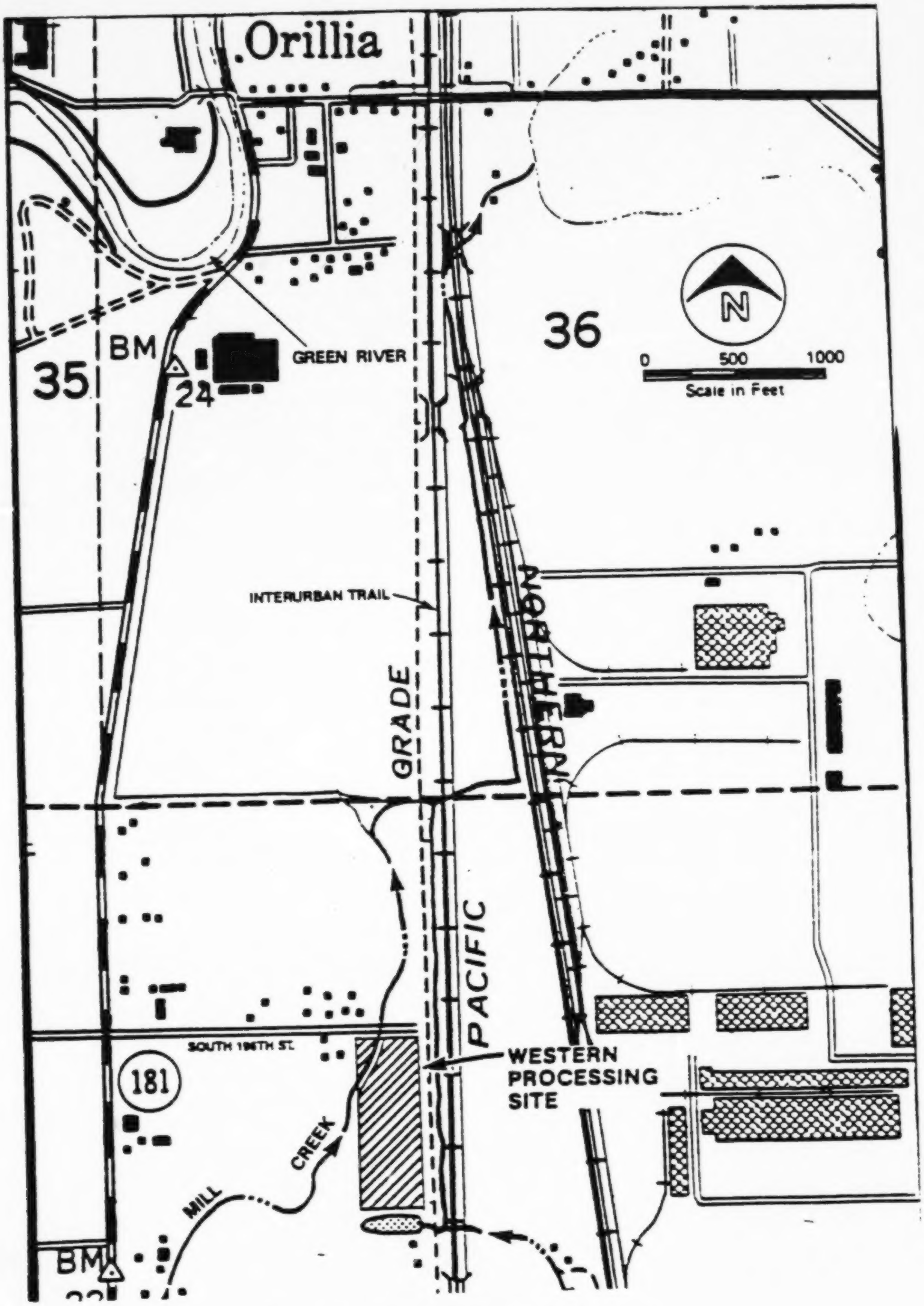

Orillia
GREEN RIVER
35
36
BM
24
N
0
500
1000
Scale in Feet
INTERURBAN TRAIL
GRADE
NORTHERN
PACIFIC
SOUTH 196TH ST.
181
WESTERN PROCESSING SITE
MILL CREEK
BM

Figure 1. Western Processing vicinity map.

TABLE 1. CHRONOLOGICAL HISTORY OF REMEDIAL ACTIVITY AT THE WESTERN PROCESSING SITE

Date	Agency	Action	Status
June 1983 - July 1983	USEPA	Removal of drummed materials and impounded liquors	Completed
Sept. 1983 - Dec. 1983	State of WA DOE	Installation of storm water controls, removal of reaction pond materials, covering excavated materials with impermeable cover, regrading site including installation of berms	Completed
Aug. 1984 - 1986	Potentially Responsible Party Coordinating Committee (PRPs)	Phase I removal of all structures including tanks, buildings, poured-in-place ponds. Removal of bulk liquids. Destruction of 7400 gallons of dioxin contaminated waste	Completed
April 1987	PRPs	Phase II-site subsurface clean up including 1, 2 dichloroethylene plume migrating away from the site. Remediation of Mill Creek sediments	In Progress

Ground water cleanup was to be accomplished through a system of vacuum extraction and infiltration wells (Figure 2). The 13 acre site was divided into seven treatment cells located to conform to the contamination profile. A total of 206 extraction wells were drilled at the site.

Cleanup requirements outlined in the amended ROD dated December 4, 1986 require installation of RCRA equivalent covers for those areas where soil contamination occurred. Additional requirements are as follows:

- Maintain a storm water control system
- Excavate contaminated Mill Creek and East Drain sediments
- Install extraction wells off site to contain a 1,2-Dichloroethylene plume
- Excavate, clean, and seal utility lines entering and leaving the site
- Perform extensive well monitoring of the ground water and Mill Creek
- Operate and maintain the ground water extraction and treatment system a minimum of five to seven years.

The ground water extraction and treatment system are both currently operational.

Process Description

Extraction wells are utilized to remove ground water from the contaminated area for treatment. City water is then pumped through infiltration trenches to flush the soil vadose zone to remove contaminants. The entire site is contained within a 40-45 ft. deep, poured-in-place, semi-impermeable, bentonite/soil barrier (slurry wall) to provide flow control and additional protection of the ground water. Four extraction wells are located offsite to remove a plume of cis-1,2 dichloroethene.

Volatile organics are removed from the extracted ground water through air stripping. Treated water is then routed to a metals treatment plant using chemical oxidation-reduction to remove phenol. Heavy metals are removed through coagulation and flocculation. Dewatered sludge is disposed in the Arlington, Oregon, EPA-approved, hazardous waste landfill.

Volatile organics and semivolatile organics are removed from the stripper air stream by passing the air flow through an activated carbon absorber. Currently, spent carbon is shipped off-site for regeneration. The PRPs installed a carbon regeneration system to strip concentrated organics from the activated carbon by passing hot air over the activated carbon bed, but the system has not been operational. A thermal oxidizer is included in the system for incineration of organics if spent carbon were regeneratd onsite. Figure 3 is a schematic of the VOC treatment system.

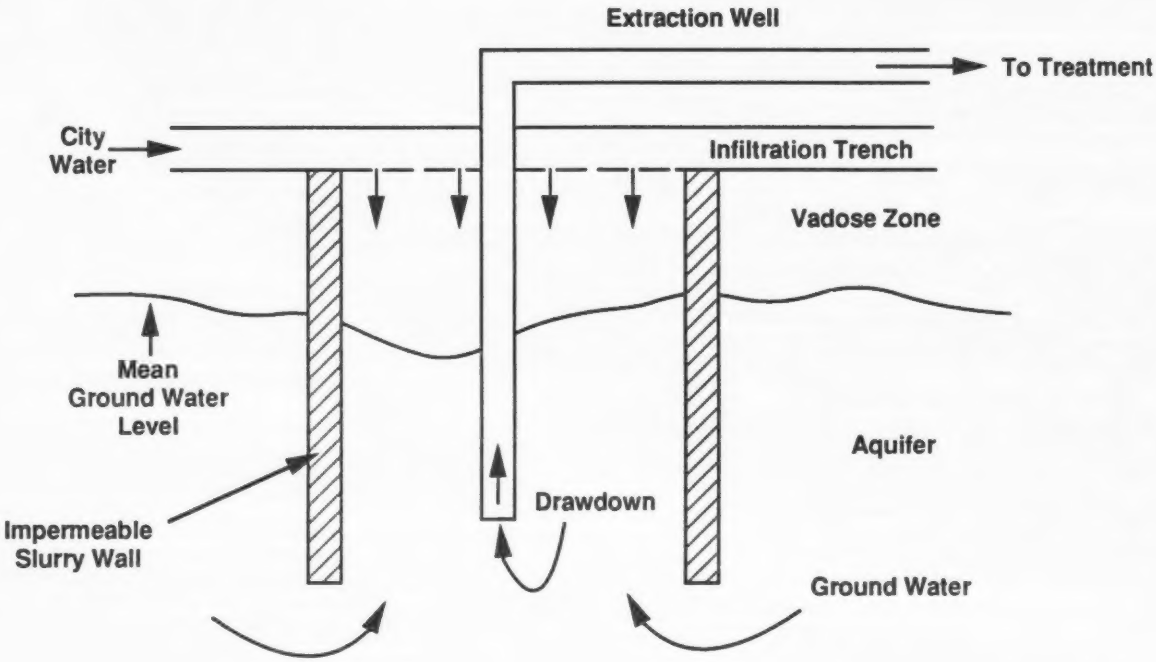

Extraction Well
To Treatment
City Water
Infiltration Trench
Vadose Zone
Mean Ground Water Level
Aquifer
Drawdown
Impermeable Slurry Wall
Ground Water

Figure 2. Western Processing Extraction Well Schematic.

MS6/6/H

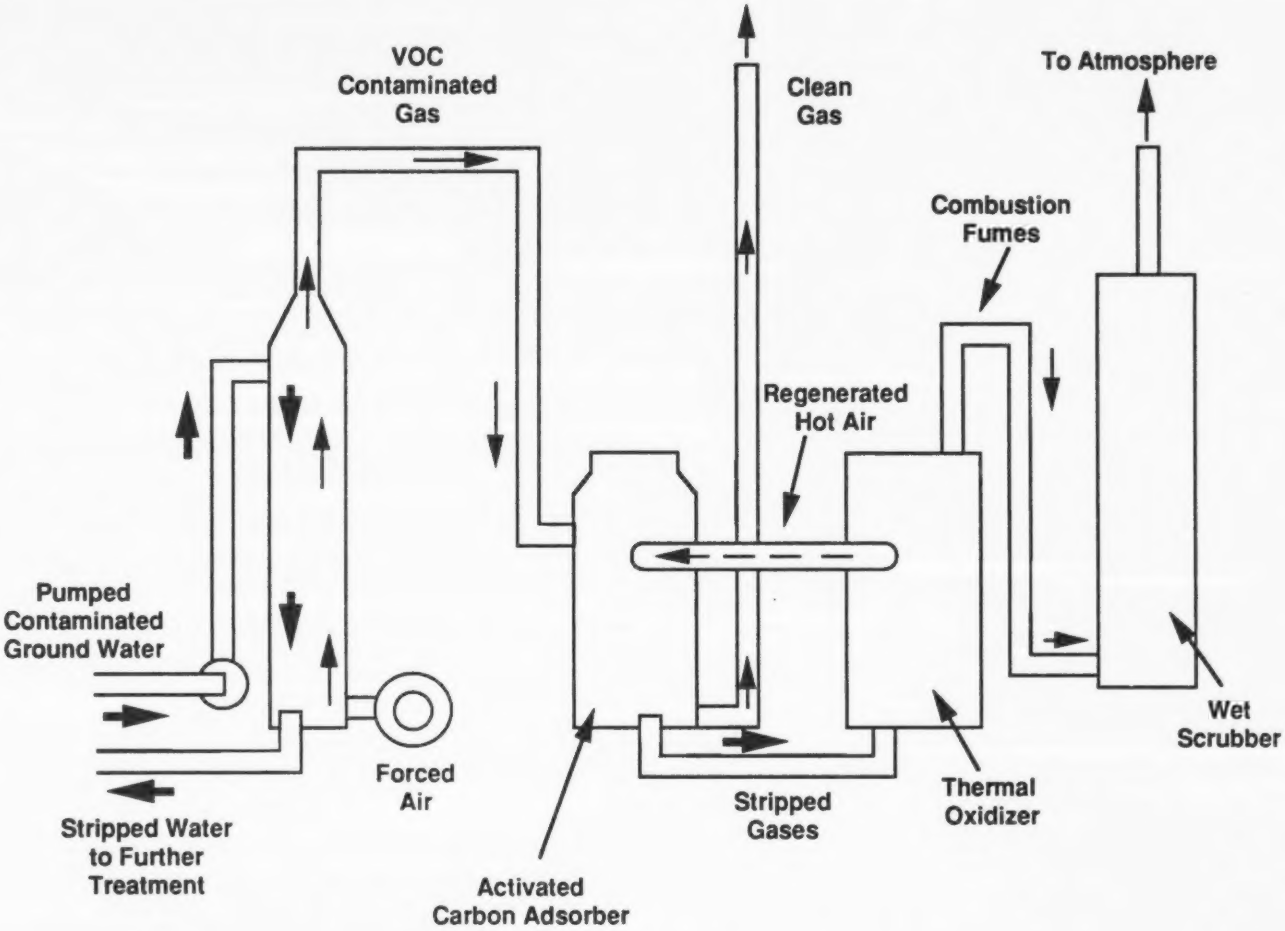

VOC
Contaminated
Gas
Clean
Gas
To Atmosphere
Combustion
Fumes
Regenerated
Hot Air
Pumped
Contaminated
Ground Water
Forced
Air
Stripped Water
to Further
Treatment
Activated
Carbon Adsorber
Stripped
Gases
Thermal
Oxidizer
Wet
Scrubber

Figure 3. VOC Treatment Tower with activated carbon adsorption for emission control and hot air stripping of activated carbon to thermal oxidizer for ultimate destruction of VOC's.

Performance Data

Removal efficiency data for the treatment system has not been released by the PRPs and is not available to the public. The treatment system effluent has exceeded permit discharge standards of 70 ppm for chloroform on several occasions.

Limited preliminary data have been submitted to the EPA detailing analytical results of sampling at Mill Creek, East Drain, and the ground water wells. It is inappropriate at this time, however, to draw any conclusions because the quantity of data is limited and the data have not been validated.

The Mill Creek water quality sampling data is available from sampling conducted from August 1987 through 1988. Several parameters from the analytical data collected from the three Mill Creek water quality monitoring stations are displayed in Table 2. Comparison of the data reveals no conclusive trends in the water quality. Priority pollutant analyses have been conducted on Mill Creek sediments, East Drain water quality samples, and Mill Creek water quality monitoring stations. Priority pollutant analyses have also been performed on 24 ground water monitoring well samples obtained in September and December 1987. However, the quantity of data is extremely limited and the data have not been validated. Mill Creek monitoring stations are depicted in Figure 4. Monitoring well locations are identified on Figure 5.

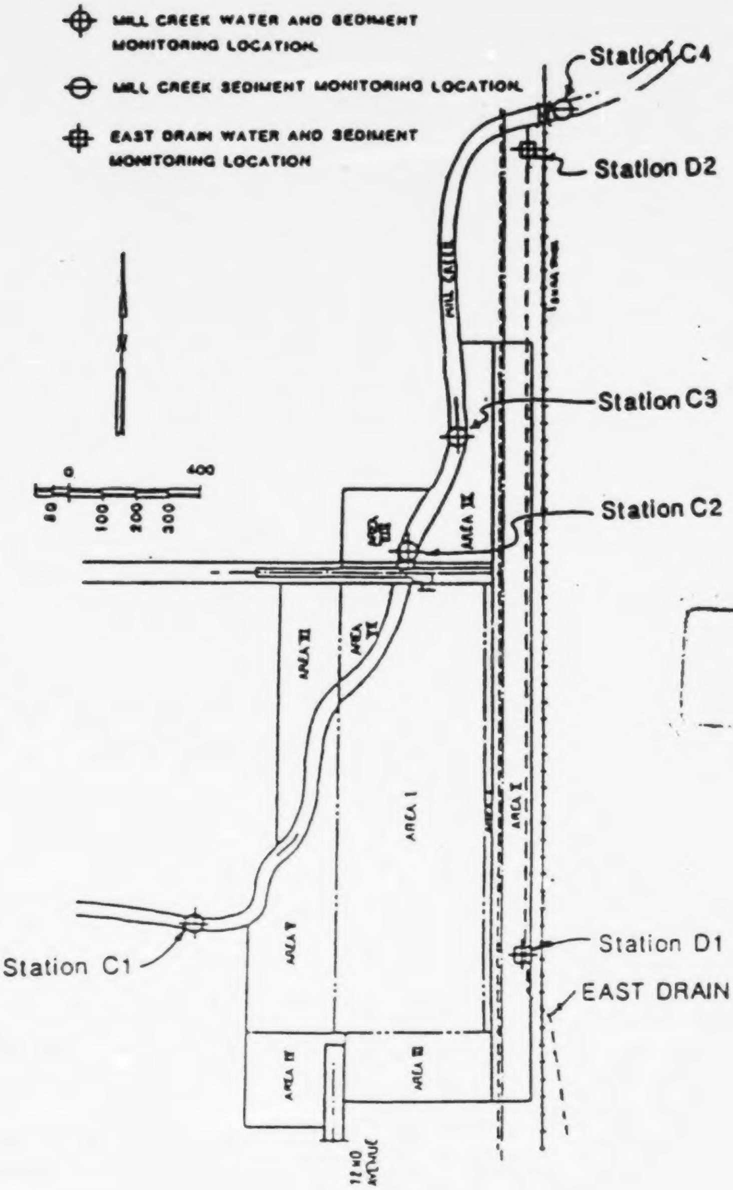
Cost Data

According to CH_2M Hill's Executive Summary Feasibility Study, the cost of the initial action taken by the U.S. EPA in 1983 was $1.4 million dollars with funding provided by CERCLA funds. The cost of Phase I surface cleanup performed by Chemical Waste Management (CWM), Inc. was approximately $9 million dollars. The PRPs were responsible for these costs under CERCLA.

The PRP's estimated cost of remediation, as published in the revised September 1986 ROD, is approximately $40,000,000, with no breakdown available. Total EPA costs to develop the ROD for this action were estimated to be approximately $6.4 million (U.S. EPA cost summary as of 11/22/88, Western Processing, Kent, Washington). Actual capital and operating costs for site remediation have not been released by the PRPs and are not available to the public. EPA's RPM estimated that the PRP has likely spent in the vicinity of $60,000,000 based on a telephone discussion of July 26, 1989.

TABLE 2. MILL CREEK WATER QUALITY

Station	C1	C2	C3
Conductivity (umhos/cm)			
1/21/88	310	344	322
12/7/87	--	--	--
11/18/87	222	239	230
10/29/87	295	328	329
9/17/87	261	293	297
8/7/87	353	462	456
Ammonia (mg/L)			
1/21/88	0.61	0.62	0.68
12/7/87	<0.05	<0.05	<0.05
11/18/87	1.4	0.65	0.64
10/29/87	0.43	0.69	0.93
9/17/87	0.62	0.87	0.92
8/7/87	0.45	1.2	1.2
TSS (mg/L)			
1/21/88	21	21	10
12/7/87	23	19	16
11/18/87	1.0	8.0	20
10/29/87	15	10	13
9/17/87	23	40	29
8/7/87	12	12	12
Total Zinc (mg/L)			
1/21/88	0.02	0.45	0.44
12/7/87	0.04	0.22	0.38
11/18/87	0.03	0.59	0.58
10/29/87	0.08	0.55	0.56
9/17/87	0.46	0.46	0.79
8/7/87	0.07	1.1	1.2


MILL CREEK WATER AND SEDIMENT MONITORING LOCATION
MILL CREEK SEDIMENT MONITORING LOCATION
EAST DRAIN WATER AND SEDIMENT MONITORING LOCATION
N
0
400
80
100
200
300
Station C4
Station D2
Station C3
Station C2
Station C1
Station D1
EAST DRAIN
MILL CREEK
AREA I

DRAFT

Figure 4. Monitoring stations, Western Processing Site.

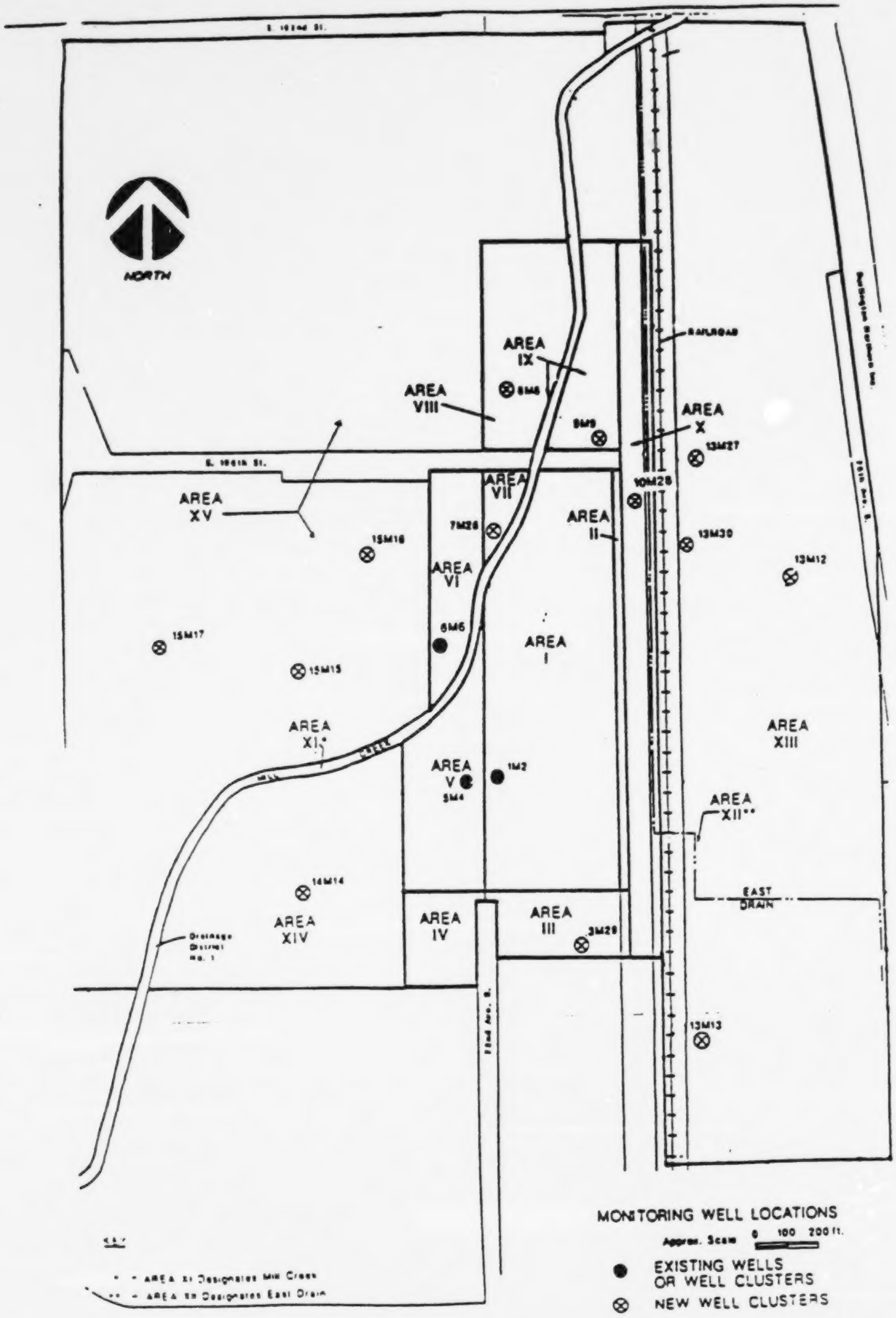

S. 192nd St.
NORTH
AREA IX
8M8
AREA VIII
9M9
RAILROAD
AREA X
13M27
S. 196th St.
AREA VII
10M28
AREA XV
7M26
AREA II
15M16
13M30
13M12
AREA VI
6M6
15M17
AREA I
15M15
AREA XI*
MILL CREEK
AREA V
5M4
1M2
AREA XIII
AREA XII**
EAST DRAIN
14M14
AREA IV
AREA III
3M29
AREA XIV
Drainage District No. 1
72nd Ave. S.
13M13
KEY
* - AREA XI Designates Mill Creek
** - AREA XII Designates East Drain
MONITORING WELL LOCATIONS
Approx. Scale 0 100 200 ft.
● EXISTING WELLS OR WELL CLUSTERS
⊗ NEW WELL CLUSTERS

Figure 5. Monitoring well locations, Western Processing Site.

REFERENCES

1. CH_2M HILL, Executive Summary Feasibility Study for Subsurface Cleanup, Western Processing, Kent, Washington. EPA 37-0L16-2. March, 1985.

2. U.S. Environmental Protection Agency. Amended Record of Decision, Western Processing, Inc. September 4, 1986.

3. U.S. Environmental Protection Agency. Cost summary as of 11/22/88, Western Processing, Kent, Washington. Provided by Loren McPhillips, RPM, EPA Region 10.

4. U.S. Environmental Protection Agency, Laboratory Data, Western Processing Superfund Site. Phase II Cleanup, U.S. EPA Region 10. 1988.

5. Site Remediation Office, Western Processing, Western Processing, Story of a Superfund Cleanup. Brochure, 1988.

6. Personal Telephone Conversation between K.W. Staten, Alliance Technologies and Herb Gaskill, Western Processing. April 4, 1989.

7. Personal Telephone Conversation between Brian Schmoyer, Alliance Technologies and Loren McPhillips, RPM, EPA Region 10. July 26, 1989.

APPENDIX J

Data Forms Used for Telephone Correspondence

Primary/Initial Contact

Name: ______________________ **Called by:** ____________

Organization: ______________________

Title: ______________________

Address/Location: ______________________

Date: ______________________ **Time:** ____________

Telephone No.: ______________________

Referred by: ______________________

Leads, Sources, Followup:

Cross-Reference:

Site Data Summary

Name: ______________________________ **Called by:** ______________

Organization/Location: ______________________________

Title: ______________________________

Date: ______________________________ **Time:** ______________

Telephone No.: ______________________________

Site:

Location:

Site Category/Lead Agency (e.g. CERCLA, RCRA, etc.):

Brief Site History and Background:

Present Status:

Remedial Action Technology(ies) Proposed or Installed:

Is there anything that makes this technology unique or innovative?

Contractor/Vendor:

Other Sources of Information about Site (Case Mgr., Publications, etc.:)

Other Considerations:

Cross References:

DATA EVALUATION

Type of Data	Quality/Quantity	Availability	Source
SITE CONDITIONS (BASELINE DATA) Hydrogeology			
Ground Water Quality			
Soil Conditions and Stratigraphy			
Other			
WASTE CHARACTERISTICS (BASELINE DATA) Volume/Quantity			
Physical Characteristics			
Chemical Characteristics			
Other			

Type of Data	Quality/Quantity	Availability	Source
REMEDIAL TECHNOLOGY START-UP DATA			
PERFORMANCE DATA **Efficiency of Removal Stream in - Stream out**			
Ground Water Quality			
Other			
POST-CLOSURE MONITORING DATA			
COST DATA **Capital**			
O & M			